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An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

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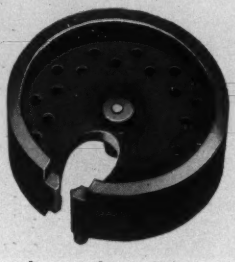

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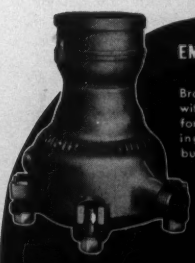

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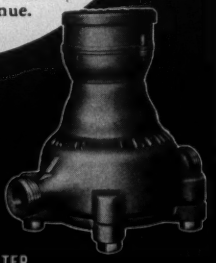

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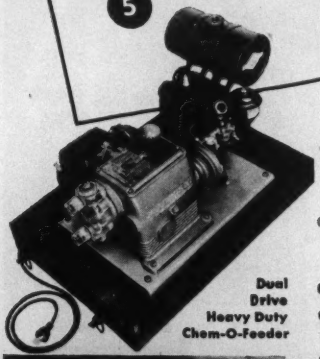

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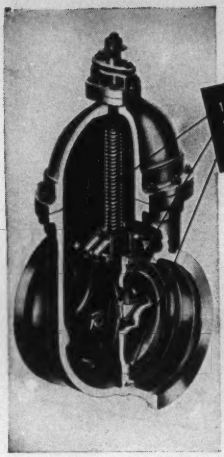

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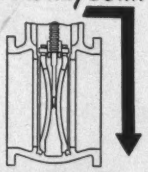

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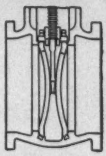

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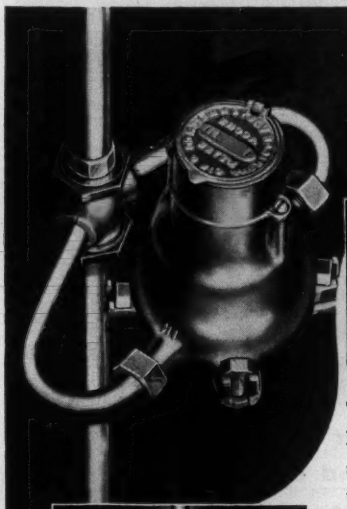

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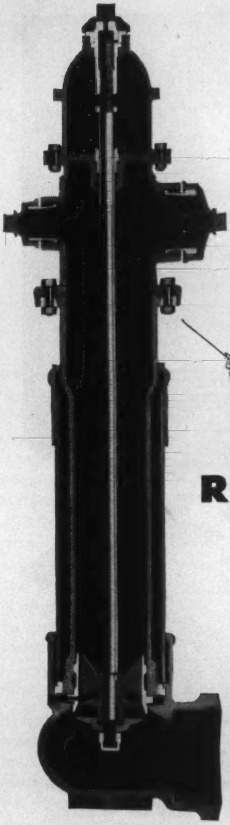

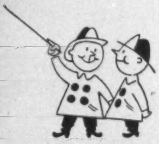

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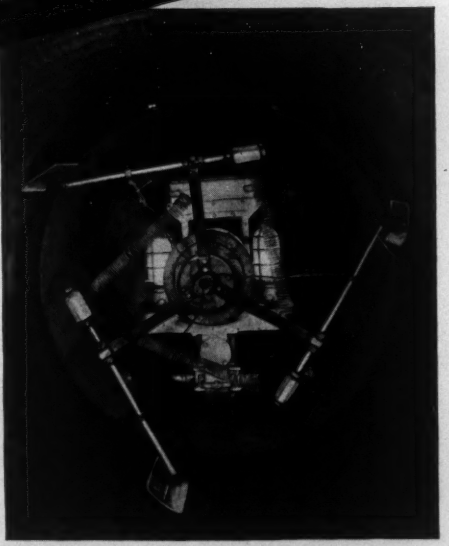

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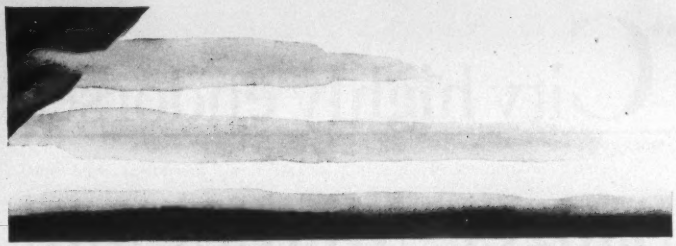

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New England Water Works Association
ORGANIZED 1882

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SOME OBSERVATIONS OF THE EFFECT OF CATHODIC PROTECTION ON RUST-TUBERCLE pH

BY F. J. LEFEBVRE AND L. P. SUDRABIN*

[*Read at Chemists' Round Table, Nov. 17, 1949.*]

Introduction

THE wide use of cathodic protection of steel in water has required the development of test methods and criteria by which the effectiveness of this means of corrosion control can be established under field conditions. Since the factors influencing electrochemical corrosion are numerous and vary in each environment, any attempt to make the criteria of protection appear overly simple will tell only a part of the story. Proper consideration should be given to the effect of environmental conditions not directly associated with corrosion processes in every observation of protection.

Briefly, there are three general methods for establishing the effectiveness of cathodic protection, which have been discussed in corrosion literature, tabulated as follows:

1. Visual and physical:
   a. Visual evidence of rust-tubercle formation.
   b. Visual evidence of pitting.
   c. Weight loss.
   d. Pit-depth measurement.
   e. Leak history.
   f. Turbidity in water resulting from active corrosion.
2. Electrical measurements:
   a. Raise the metal-water potential to a fixed value.
   b. Raise the metal-water potential by a fixed amount.
   c. Potential-log current density relationship.

*Electro Rust-Proofing Corp., Box 178, Newark 1, N. J.

3. Chemical:
   a. pH of rust tubercle.
   b. Tubercle anion and cation concentration.
   c. Iron pickup in water resulting from active corrosion.

Very little work has been reported on the chemical criteria of corrosion control and it is the intent of this paper to outline some possibilities of this method in practical field work.

Since cathodic protection is very often applied to submerged steel structures already showing evidence of corrosion attack, it is frequently difficult to determine whether cathodic protection is effective by the usual visual or physical methods. One may take, for example, a new unpainted tank, which has been in contact with water for some time and has rust-tubercle formation before cathodic protection is applied, or a painted tank where intense pitting with tuberculation has occurred at the breaks in the coating. In waters containing less than 50 ppm of $CaCO_3$ hardness, corrosion control by cathodic protection can be complete without any easily discernible change in the visual or physical character of the previously formed rust. If iron anodes are used or soluble iron is present in the water, the iron will tend to migrate and accumulate on the cathode as iron hydroxide. This rust may lead the inspector falsely to believe that corrosion is occurring.

One practice which has been widely adopted to establish the effectiveness of corrosion control is to clean manually all rust, paint and other accumulation from a designated area of the submerged surface at the time that cathodic protection is first applied. Then a subsequent visual examination of this area is made, after the protection has been applied for some time. Unfortunately, this procedure will not allow a valid interpretation to be made of the effectiveness of the particular cathodic protection system on the remainder of the unconditioned submerged area.

First, the value of paint coatings in limiting the protective current requirements is well known and the removal of all paint from the designated area immediately increases the protective current requirements. Thus, even though adequate current is applied to prevent further attack on the unconditioned area, the bare area may show visual evidence of corrosion.

Secondly, the influence of rust and the accumulation of other foreign matter on steel surfaces upon protective current requirements is less well known. Observations in sea water (1) show a definite value derived from the accumulation of rust in reducing protective current requirements. Unreported work by the authors indicates that the protective current density required to prevent any corrosion of a clean, hot-rolled steel surface in an aerated soft water is in the neighborhood of 15 ma/sq ft. A protective current density of 5 ma/sq ft will be adequate to prevent further corrosion attack, if the steel has undergone free corrosion for a period of three months and the stabilized corrosion-product accumulation remains on the surface of the steel. The economics of preventing further corrosion of a previously corroded steel surface over preventing even initial attack of a new, unattacked steel surface becomes evident.

Since corrosion test specimens usually do not possess surface conditions which are characteristic of the submerged steel structure itself, all conclusions drawn from such tests should be carefully weighed.

It has been the intent of the previous discussion to show that the practical interpretation of corrosion control can often be complex and that the most adequate observation can best be made by experienced corrosion engineers, competently familiar with the tools and techniques available for the evaluation of cathodic protection. Rust-tubercle pH measurements seem to offer a useful tool, which will go hand-in-hand with the other techniques more commonly used by the corrosion engineer.

Earlier Work

Thus far comparatively little work has been done on the nature of the solutions enclosed within a rust tubercle covering a pit. Baylis (2, 3) noted that the active tubercles on the inside of Baltimore water pipes contained solutions having a pH of about 6.0 or less. This pH appeared to be independent of the pH of the bulk of the water in the pipe. He also observed that the pH of tubercles which appeared dormant varied between 6.4 and 6.8. A tubercle was assumed to be inactive when a firm, continuous membrane without breaks extended over its surface. In some cases more than 1% of

chloride and sulphate was measured in the layer of corrosion product covering the pit. This concentration of these anions was many times the concentration of the same anions in the water and suggests their migration through the solution to the pit or local anode in the electrochemical corrosion cell.

More recently studies have been reported on synthetic corrosion pits by Lochte *et al.* (4). These were produced by exposing one end of an iron wire (anode) in the bottom of a vertical glass tube and supporting a coil of copper wire (cathode) above the tube. The iron and copper wires were coupled to complete the corrosion circuit. This assembly was placed in a glass beaker, containing 9 parts of 0.1N NaCl and 1 part by volume of 0.1N NaOH. The solution had an initial pH of about 12.0, which gradually dropped in the presence of CO_2 from air contact to a pH of 8.85-8.86.

Corrosion products started to form in the bottom of the glass tube within a matter of minutes, and an analysis of the solution below the rust membrane which separated the corrosion product from the overlying solution indicated a pH ranging from 5.8 to 6.3. Further study showed that the synthetic tubercle consisted of several layers of rust, separated by membranes, the solution closest to the iron wire having a pH as low as 5.2. The pH gradually increased as the outer layers of rust were reached. Similarly, it was noted that the Cl^--ion concentration increased in the lower rust layer over that in the bulk of the solution and, correspondingly, the Na^+-ion concentration decreased, demonstrating the transport of ions to their respective attracting poles through the electrical field of the corrosion cell.

Characteristic deposits are formed on hot-rolled steel surfaces when a protective condition is attained in waters having large amounts of easily deposited scale-forming salts (see Fig. 1).

Since the precipitation of scale-forming salts is a function of hydroxyl ion available, it becomes apparent that, when the protective current exceeds the minimum required for cathodic protection, a higher current density is received by the area normally the local anode in the freely corroding cell than by the adjoining cathodic areas. This can be explained by the relatively high electrical film resistance of the cathode area compared to that of the anode area (7). The protective current distribution is largely determined by the relative film resist-

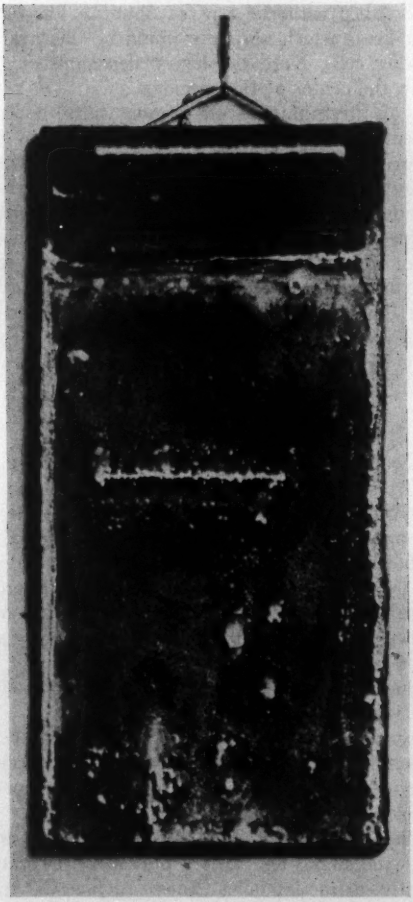


FIG. 1.—DEPOSITS FORMED ON HOT-ROLLED STEEL SURFACE WHEN PROTECTIVE CONDITION IS ATTAINED IN SCALE-FORMING WATER

ances in accordance with the Law of Shunts. The heaviest deposit develops over areas which normally would be the local anode of the freely corroding cell. Note the heavy deposit over the horizontal scratch line in the center of the specimen.

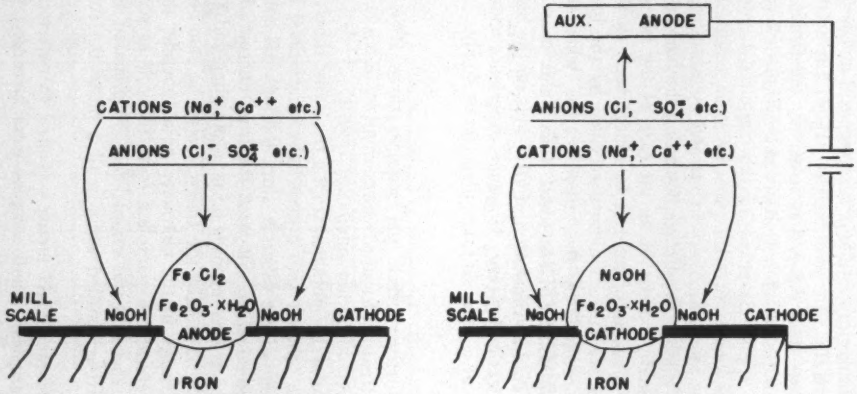
A layer of precipitated scale-forming salts, covering tubercles which had formed at failures in paint coatings prior to the application of cathodic protection, is commonly observed (5) when the water contains easily deposited scale-forming salts. Since there usually is no visible evidence of a deposit within the rust tubercle, it appears that, when the protective current-density requirements are exceeded, a high pH solution accumulates within the tubercle, some of which then diffuses through the outer membrane, precipitating the salts from the water on the outside of the tubercle. This would suggest that, in soft Eastern waters containing very little scale-forming salts, an increase in the pH of the rust tubercle will also represent a protective condition.

Theory

U. R. Evans (6) has very aptly described the electrochemical corrosion of iron as a process in which iron goes into solution at a bare spot, oxygen is reduced on the mill or oxide scale, and the rust or hydroxide appears at a third place. The mechanism of the active corrosion of hot-rolled steel in aerated water is illustrated in Fig. 2A. The exposed iron at the break in the mill scale is the anode and the intact mill scale acts as the cathode. The corrosion of iron at the anode introduces Fe^{++} ions, to form a tubercle at some distance from the anode, and at the same time an equivalent amount of O_2 and/or H^+ ions is reduced on the mill scale, with the result that a preponderance of OH^- ions is produced.

The presence of the accumulated OH^- ions on the cathode can be readily seen by the pink color developed when phenolphthalein indicator is added to stagnant water and the surface of the steel plate is examined under an oblique light.

Meanwhile the electrical field between the local anode and the cathode causes the anions and cations present in the water to migrate to their respective attracting poles. Anions such as Cl^- and $SO_4^=$ move to the anode and the cations Na^+, Ca^{++} and Mg^{++} are attracted to the



A. ACTIVE CORROSION (AERATED WATER)

B. CATHODIC PROTECTION STIFLED CORROSION (AERATED WATER)

NOTE – ONLY Na^+ AND Cl^- IONS USED TO ILLUSTRATE EFFECT OF ION MIGRATION.

Fig. 2

cathode areas. The soluble ferrous chloride and/or sulphate tending to accumulate in the rust tubercle are salts of a strong acid and weak base, which hydrolize acidically. In practice, the pH of active rust tubercles is found to be less than 6.5 and is relatively independent of the pH of the bulk of the water, as first observed by Baylis (2, 3).

A protective current, applied in excess of that required to stop further corrosion of a previously corroded piece of steel, results in the migration of the anions to the auxiliary anode and the accumulation of OH^- ions over the whole steel surface, including the bare spot (see Fig. 2B). This gradually results in an increase of the pH of the rust tubercle. It may now be of interest to reflect back to the observation that the protective current density received by the bare area is greater than that received by the cathodic areas, when the minimum protective current density is exceeded. This higher current density results in a more rapid accumulation of OH^- ions on the bare spot than on the adjoining cathodic areas. However, experience shows that the net change in pH of a tubercle takes place quite slowly.

Test Technique

The measurement of rust-tubercle pH requires three steps—namely, sampling, sample treatment and pH measurement. Each step must be carefully considered to obtain significant results.

First, the sample is preferably obtained from a fresh rust tubercle by drawing the core of the tubercle into a glass tube. Care must be taken not to sample the edge of the tubercle, since the high pH solution of the cathode-tubercle interface will mask the true tubercle pH. In cases where the tubercle has been exposed prior to sampling and has dried out, the rust from the center of the tubercle may be sampled. Because of the possible change in the character of a tubercle, due to exposure to air, it is preferable to sample a fresh tubercle as soon as it is exposed. A dried rust-tubercle sample may be prepared for pH measurement by admixing distilled water until a paste-like consistency is attained.

A Beckman laboratory-model pH meter was used to determine the pH of the tubercle samples. Small samples were measured by using a Beckman, #290-K, sealed, drop-size glass electrode.

Observations

Data have been obtained on the pH of active tubercles in waters whose pH ranged from 6.4 to 8.85. Wherever possible, the pH of the tubercle was measured again, after cathodic protection had been applied and it had been established that further metal attack was being prevented. It will be noted in Fig. 3 that the pH values of the active rust tubercles observed are all less than 6.5 and are independent of the pH of the water. Cathodic protection, when adequately applied, raised the pH of all previously active tubercles to 7.0 or above.

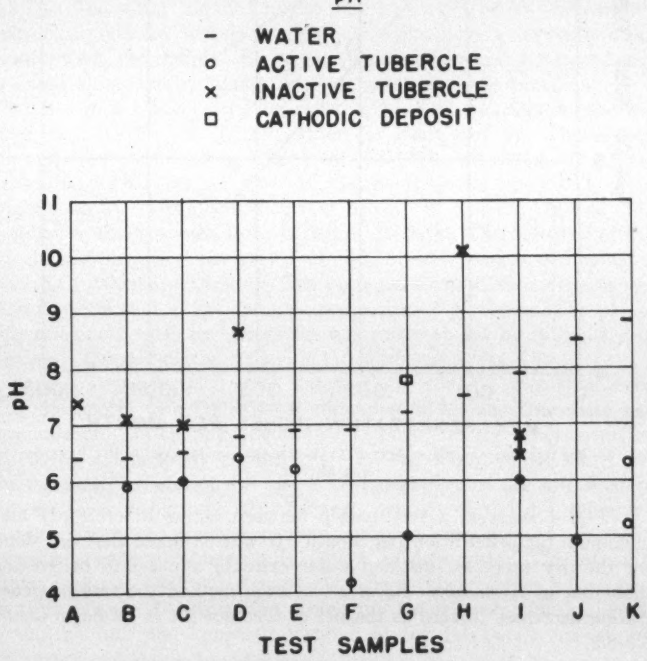


FIG. 3.—OBSERVED pH VALUES OF RUST TUBERCLES.

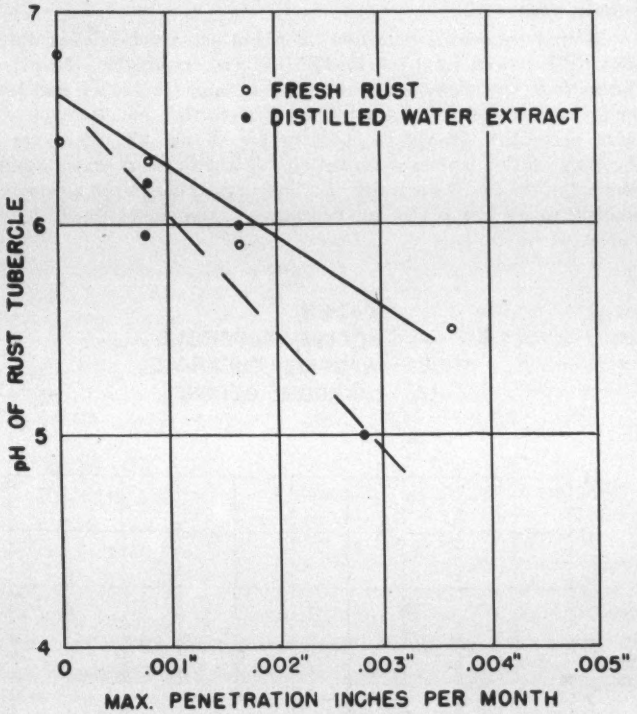


FIG. 4.—RELATIONSHIP BETWEEN ACTIVE TUBERCLE pH AND MAXIMUM PIT PENETRATION PER MONTH.

Fig. 4 suggests a relationship between active tubercle pH and maximum pit penetration per month. It will be noted that the slope for the dry tubercle (distilled water extract) appears to be greater than that of fresh rust. However, in each method the rate of penetration decreases to zero as the pH of the tubercle is raised to about 6.5-6.6.

It is of particular advantage to be able to establish the maximum rate of penetration or the absence of attack from a pH measurement of the rust tubercle.

A brief description of each pH measurement shown on Fig. 3 follows:

A. Rust-tubercle samples were taken from a 50,000-gal, Massachusetts, state-institution elevated tank. Prior to the time when cathodic protection was installed, the water appeared rusty and a great deal of tuberculation was observed on the submerged areas.

After cathodic protection had been applied, the tubercle samples, which were taken dry and treated with distilled water, had a pH of 7.4. The water confined in the tank had a pH of 6.4. The water was clear and no further evidence of rust-tubercle formation was noted, when the sample was taken. Aluminum anodes were used and a slight aluminum-hydroxide floc was noted over the tubercles.

B. A 4″×8″×1/16″, hot-rolled steel plate was allowed to corrode in Belleville, N. J., tap water for eight months. The pH of several fresh tubercles measured was 5.9. The maximum pit depth, measured with a Starret, #640-E, dial depth gauge was 0.013 in. in eight months. A protective current density of 5 ma/sq ft was then applied to the specimen for a period of 20 days. The potential of the steel plate to water was raised to —0.785 volt, measured against a sat. KCl calomel electrode. This potential is used as a criterion to assure protection in the cathodic protection of pipelines. The pH of the remaining fresh rust tubercles was raised to 7.1 by cathodic protection. The pH of the Belleville tap water used was 6.4.

C. Two hot-rolled steel plates, 6″×6″×3/32″, were submerged for six months in a 300,000-gal standpipe in Maine. One plate was grounded to the cathodically protected tank and the other insulated so as to act as freely corroding steel. The water stored has a pH in the neighborhood of 6.5 and is representative of the soft Eastern waters. The pH of the distilled-water extract of the dry tubercles, sampled from the freely corroding specimen, was 6.0 and the maximum pit penetration measured 0.010 in. in six months. The cathodically protected specimen showed much less tuberculation and apparently was only slightly active during the hot summer months. However, the tubercles appeared inactive in the fall, when the sample

was removed. The pH of the dry tubercles was 7.0 and the maximum penetration was 0.001 in. in six months.

D. An unprotected test plate, 4″×8″×1/16″, submerged in Belleville, N. J., water prior to Test B, had a fresh rust-tubercle pH of 6.35 and a maximum penetration rate of 0.005 in. in six months. This tubercle sample was allowed to dry out and a pH of the distilled-water extract measured 5.95. The Belleville water, which is typical of soft, aggressive Eastern waters, at the time had the following analysis:

Sp. resistance	— 11,480 ohms at 28° C.
pH	— 6.8
Total alk.	— 19 ppm
P.P. alk.	— 0 ppm
Hardness	— 27 ppm
Dissolved O_2	— 7 ppm

A third test plate, 2″×8″×1/16″, submerged in Belleville water, developed pits 0.013 in., 0.013 in., 0.011 in. and 0.009 in. deep, respectively, in three months. The average fresh rust-tubercle pH of the four pits was 5.5.

E. Two, 6″×6″×3/32″, sandblasted steel plates were suspended in a cathodically protected standpipe in New Hampshire for six months. One specimen was grounded, and the other insulated and freely corroding. The grounded specimen showed no evidence of corrosion. The pH of the dry tubercle extract of the freely corroding specimen was 6.2 and the maximum penetration rate was 0.005 in. in six months. The pH of the water was about 6.9 and represented a soft, aggressive type.

F. Dry rust tubercles, taken from a Florida public-utility tank, confining a brackish water, had a pH of 4.2. The pitting activity at breaks in the paint film was very intense. The pH of the brackish water was 6.9.

G. Two, 6″×6″×3/32″, hot-rolled test plates were installed for six months in a Pennsylvania paper-mill tank, through which very soft, aggressive Delaware River water with a pH of 7.2 is continuously flowing. The freely corroding tubercles had a pH of 5.0 in a distilled-water extract. The maximum penetration of the unprotected

specimen was 0.017 in. in six months. The cathodically protected specimen showed no corrosion attack. A white deposit covered the weak points on the mill-scale surface and had a distilled-water extract pH of 7.8.

H. The tubercles which had formed prior to the application of cathodic protection in another Florida public-utility tank, confining brackish water, were found covered with a white deposit and had a distilled-water extract pH of 10.3. The brackish water has a pH of 7.5.

I. J. R. Baylis reported a fresh rust-tubercle pH of 6.0 in the solution enclosed in active pits and a pH of 6.4-6.8 in dormant pits. The Baltimore water in contact with the tubercles had a pH of 7.9.

J. Tree-like tubercles, found on the floor of a hot-water storage tank, had a distilled-water extract pH of 4.9. The pH of the water stored was 8.5. Very intense pitting was noted.

K. Lochte and others reported that the pH of synthetic rust tubercles ranged from 5.2 to 6.3 in contact with an NaCl-NaOH solution, buffered by CO_2 from air having a pH of 8.85-8.86.

Anaerobic Corrosion

In active rust tubercles the presence of a pH of 6.0-6.5 along with sulfate and ferrous ions will create a favorable environment for anaerobic bacteria, such as *S. desulfuricans*, to influence the corrosion process. These anaerobic bacteria may exist within the tubercle, even though the surrounding environment is well aerated (8). It has been established that the activity of sulfate-reducing bacteria is limited, when the pH of the medium in which they exist is raised above 8.5-9.0 (9, 10).

Thus, the increase in pH of a rust tubercle by cathodic protection to 9.0 at the metal surface should control most bacterial corrosion.

Conclusions

The preliminary work, conducted on the effect of cathodic protection on rust-tubercle pH, suggests:

1. Active corrosion tubercles have a pH less than 6.5.
2. The pH of the tubercles decreases, as the rate of pit penetration increases.

3. The pH of active tubercles is relatively independent of the pH of the bulk of the water.
4. Cathodic protection, when complete, raises the pH of a tubercle above 7.0 and in time the pH should approach 9.0.
5. Measurement of the pH of a rust tubercle provides the Corrosion Engineer with an additional tool, to establish the effectiveness of cathodic protection.

Study is being continued, to develop further the relationship of rust-tubercle pH to the intensity of pitting.

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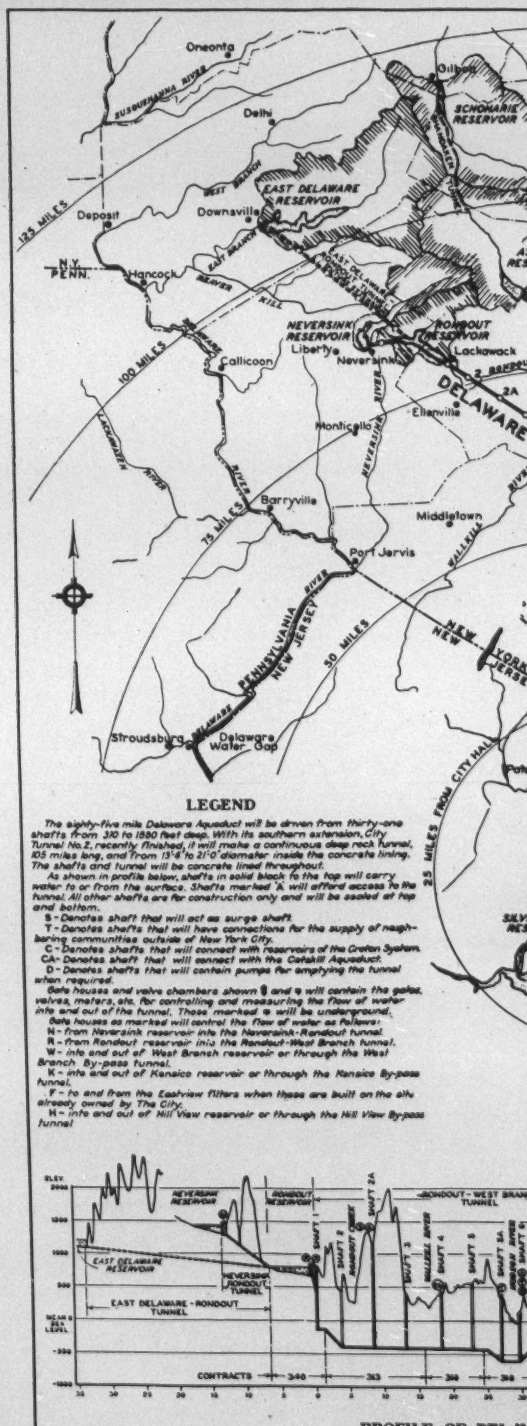
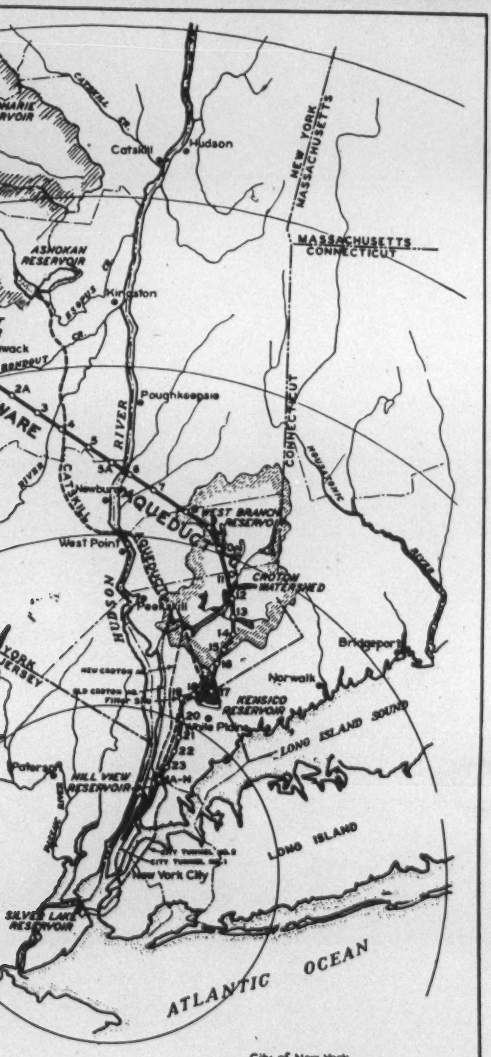
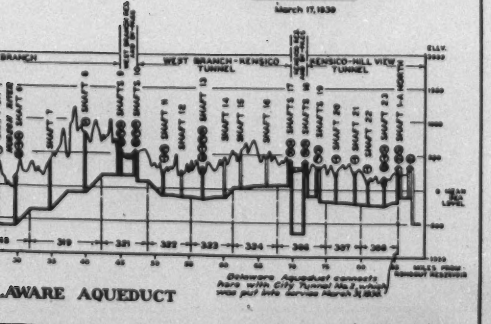

Oneonta
Delhi
Deposit
Downsville
Hancock
N.Y. PENN.
Callicoon
Liberty
Neversink
Lackawack
Ellenville
Monticello
Barryville
Middletown
Port Jarvis
Stroudsburg
Delaware Water Gap
SUSQUEHANNA RIVER
DELAWARE RIVER
NEVERSINK RIVER
WALLKILL RIVER
PENNSYLVANIA
NEW JERSEY
EAST DELAWARE RESERVOIR
NEVERSINK RESERVOIR
RONDOUT RESERVOIR
SCHOHARIE RESERVOIR
125 MILES
100 MILES
75 MILES
80 MILES
25 MILES FROM CITY HALL
DELAWARE
LEGEND
The eighty-five mile Delaware Aqueduct will be driven from thirty-one shafts from 310 to 1580 feet deep. With its southern extension, City Tunnel No.2, recently finished, it will make a continuous deep rock tunnel, 105 miles long, and from 13'6" to 21'0" diameter inside the concrete lining. The shafts and tunnel will be concrete lined throughout.
As shown in profile below, shafts in solid black to the top will carry water to or from the surface. Shafts marked 'A' will afford access to the tunnel. All other shafts are for construction only and will be sealed at top and bottom.
S - Denotes shaft that will act as surge shaft.
T - Denotes shafts that will have connections for the supply of neighboring communities outside of New York City.
C - Denotes shafts that will connect with reservoirs of the Croton System.
CA - Denotes shaft that will connect with the Catskill Aqueduct.
D - Denotes shafts that will contain pumps for emptying the tunnel when required.
Gate houses and valve chambers shown ● and ▼ will contain the gates, valves, meters, etc. for controlling and measuring the flow of water into and out of the tunnel. Those marked ● will be underground.
Gate houses as marked will control the flow of water as follows:
N - from Neversink reservoir into the Neversink-Rondout tunnel.
R - from Rondout reservoir into the Rondout-West Branch tunnel.
W - into and out of West Branch reservoir or through the West Branch By-pass tunnel.
K - into and out of Kensico reservoir or through the Kensico By-pass tunnel.
F - to and from the Eastview filters when these are built on the site already owned by The City.
H - into and out of Hill View reservoir or through the Hill View By-pass tunnel
NEVERSINK RESERVOIR
RONDOUT RESERVOIR
RONDOUT - WEST BRANCH TUNNEL
EAST DELAWARE RESERVOIR
NEVERSINK-RONDOUT TUNNEL
EAST DELAWARE - RONDOUT TUNNEL
SHAFT 1
SHAFT 2
SHAFT 2A
SHAFT 3
SHAFT 4
SHAFT 5
SHAFT 5A
CONTRACTS
340
313
PROFILE OF DELA

FIG. 1.—PLAN AND PROFILE OF THE DELAWARE WATER SYSTEM, AND THEIR RELATION TO THE EXISTING CA



City of New York
BOARD OF WATER SUPPLY
DELAWARE AQUEDUCT
PLAN AND PROFILE
March 17, 1939



M, Showing the Locations of the Reservoirs and Tunnels Catskill and Croton Water Systems.

POWER GENERATION FROM THE DELAWARE PROJECT

BY GEORGE R. RICH*

[*Read Nov. 17, 1949.*]

PRIOR to construction of the Delaware water supply, the city of New York secured by condemnation proceedings the right to divert the flow of certain streams, upon which were located existing and projected water-power plants of two private utilities, the Central Hudson Gas & Electric Corp. and the Rockland Light & Power Co. Under such circumstances, the power companies usually seek relief from the law courts in the form of money damages; but in this particular instance, the availability of energy generation at the tunnel outlets forms the basis of interesting agreements between each utility and the city. In essence, each power company will be permitted to construct a hydroelectric power station at the outlet of one of the two pressure tunnels which empty into the Rondout storage reservoir; the water to be consumed by the city will constitute the water supply to the power stations; after fifty years the power stations will become the property of the city; in the meantime, the revenue from the sale of power will amortize the damage to the water-power privileges and the cost of power-station construction.

THE DELAWARE WATER SUPPLY

From the upper reaches of certain tributaries of the Delaware River and from Rondout Creek, a tributary of the Hudson, all within the state of New York and all rising on and flowing down the southern and southwestern slopes of the Catskill Mountains, the city of New York is now developing an additional supply of 440 mgd from the Delaware watershed plus 100 mgd from the Rondout watershed.

The plan now underway provides for the development of the new source in two stages (see Figure 1):

First Stage: Construction of the reservoirs on the Neversink River and Rondout Creek, together with the tunnel connecting the Never-

*Partner, Chas. T. Main, Inc., 80 Federal St., Boston 10, Mass.

sink and Rondout reservoirs and the main aqueduct from Rondout Reservoir to the present Hill View Reservoir, located just above the city of New York in the city of Yonkers, thus making available a new and additional supply of water of 205 mgd.

Second Stage: Construction of the Pepacton Reservoir on the East Branch of the Delaware River and East Branch Tunnel to the Rondout Reservoir, so as to make available 335 mgd of new and additional water, and bring the total for the new system up to 540 mgd. The aggregate supply from all available sources would then be about 1,600 mgd.

Legal Features

The Delaware River is an interstate stream, marking the boundary between New York and Pennsylvania in the upper reaches and between Pennsylvania and New Jersey below. The abstraction of water from the upper reaches of the river by the city of New York involved extensive litigation, which culminated in a decree by the United States Supreme Court, permitting the city to divert 440 mgd of water and stipulating certain specific releases from the city's reservoirs, to augment low flows on the Delaware:

> "At any time the stage of the Delaware River falls below 0.50 csm at Port Jervis, New York, or Trenton, New Jersey, or both (0.50 csm being equivalent to a flow of 1535 cfs at Port Jervis and 3400 cfs at Trenton), water shall be released from one or more of the impounding reservoirs of New York City in sufficient volume to restore the flow at Port Jervis and Trenton to 0.50 csm, provided, however, that there is not required to be released at any time water in excess of 30 per cent of the diversion area yield, and the diversion area yield having been ascertained to be 2.2 csm, the maximum release required shall be 30 per cent of that amount, or 0.66 cubic feet per second per square mile of the areas from which water is diverted."

This decree increased the storage requirement of Neversink Reservoir from 10 billion to 37 billion gallons and added quite materially to the total project cost, which is now estimated as about $440,000,000 to the end of the second stage.

The New York state law authorizing the agreement between the utilities and the city of New York is as follows:

"Laws of the State of New York, 1946—Section K 41-48.0—Utilization of water to generate electric current—The Board of Water

Supply may, subject the approval of the board of estimate, utilize such water as it now owns or as it may hereafter acquire, for the purpose of generating electric current for the use of the municipality, or may permit the utilization of such water for the generation and sale of electric current by an electric corporation which was the owner of a developed or undeveloped water power site or sites affected, acquired or damaged by the execution of a plan or project of the City for an additional water supply, and the board of water supply, with the approval of the board of estimate, in connection with the settlement of a resultant claim for damages made by such electric corporation, may grant or lease to such electric corporation for periods not to exceed fifty years, rights in, or to use, the lands and waters of the City for the generation of electric current as herein provided, for such consideration and on such terms and conditions as are, in the opinion of such board, in the best interests of the City of New York, including but not limited to a general release of such claim, provided that such grant or lease may be made at the time of settlement of the claim as above provided but the period of use under the terms of the lease or grant, not to exceed fifty years, may commence when generation of electric current thereunder shall begin, provided that no additional water shall be used for such purpose than would otherwise be required by the City."

Storage Reservoirs

The essential physical features of each of the three storage reservoirs is given in Table 1.

Table 1.—Reservoir Statistics

	Rondout	Neversink	Pepacton
Drainage Area—Square Miles	95	93	372
Flow-Line Elevation—Feet	840	1,440	1,280
Available Storage—Billion Gallons	48.7	34.7	143.5
Area Water Surface—Acres	2,100	3,070	5,700
Type of Dam	Earth	Earth	Earth
Height of Dam—Feet	195	195	204
Length of Dam—Feet	2,400	2,820	2,450
Length of Tunnel—Miles	85	5	25
Diameter of Tunnel—Feet	13.5-19.5	10	11.33
Mean Annual Runoff—Inches	31.0	35.1	27.0

Because bedrock in each case lies deep below the ground surface of the valley, the dams have been constructed principally as earth embankments. At the Merriman Dam site at Lackawack, the valley above the rock floor is filled with sand, gravel and clay to a maximum depth of 180 ft below the surface of the valley bottom. This great depth of water-bearing over-burden required the construction of a concrete cutoff wall from the surface to bedrock. The deepest portion of the cutoff was constructed as a succession of 20 caissons, sealed into the ledge rock and to each other.

The Delaware Aqueduct

As shown by Figure 1, delivery of water from the Rondout Reservoir to the Hill View Reservoir, just outside of the New York City line, is accomplished by the Delaware Aqueduct, 85 miles in length. The aqueduct is a deep-lying pressure tunnel, driven in solid rock, circular in section and lined with concrete throughout. The finished diameter of the tunnel varies as follows: from Rondout Reservoir to West Branch Reservoir, 13½ ft; from West Branch Reservoir to Kensico Reservoir, 15 ft, and from Kensico Reservoir to Hill View, 19½ ft.

The progressive increase in tunnel diameter is due to several causes:

(1) An increase in flow of about 40 mgd from the West Branch Reservoir.
(2) A progressive reduction in available head, the head being 337 ft Rondout to West Branch, 148 ft West Branch to Kensico and 60 ft Kensico to Hill View.
(3) The tunnel from Rondout to West Branch is designed for a nominal maximum flow of 980 mgd but will take more; when the new West Branch to Kensico section is available, the flow will be 1,000 mgd.
(4) The Kensico to Hill View tunnel is designed to carry about 1,700 mgd and so will take the combined flow of the Catskill and Delaware systems, if necessary.

The Neversink Power Station

The mode of operation of the Neversink Reservoir and the intensity and duration of flow available at the Neversink tunnel outlet are dictated primarily by the water-supply requirements of the city of New York. Under the terms of the contract between the Central

Hudson Gas & Electric Corp. and the city, Central Hudson is required to take 100 million cu ft of water per week and pay for the excess over 3.2 billion cu ft per year at the rate of $26.50 per million cu ft. The utility would also pay for water used in excess of the aforesaid 100 million cu ft per week at the rate of $26.50. Thus Neversink plant is adapted to operate primarily on daily peak load service 8 hours per day, 5 days per week, as indicated by the power-duration curve, Figure 2.

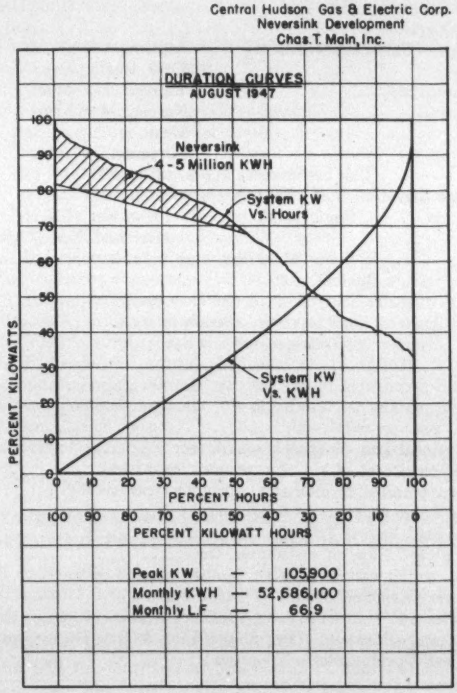


FIG. 2.

The pertinent physical features of the project are given in Table 2.

TABLE 2.—PERTINENT PHYSICAL DATA—NEVERSINK POWER STATION

1.	Name of Power Company .... Central Hudson Gas & Electric Corporation		
2.	Name of Project ..... Neversink Tunnel		
3.	Name of River ..... Neversink		
4.	Consulting Engineers ..... Charles T. Main, Inc.		
5.	Designing Engineers ... Chas. T. Main, Inc. and New York City Board of Water Supply as part of the Delaware Water System		
6.	Project Started ..... December, 1948		
7.	Initial Operation ..... July, 1952		
8.	Dam, type—Earth Embankment	Maximum height, feet	195
		Crest length, feet	2,820
9.	Headwater, feet	Extreme Maximum	1,447
		Normal Maximum	1,440
		Mean	1,421
		Minimum	1,352
	(Can be drawn to 1,320; sill at 1,311)		
10.	Tailwater Elevation, feet (for 785 cfs)		889
11.	Heads, feet ..... Static Maximum 551—Mean Net (730 cfs)		474
		Minimum Net (785 cfs)	396
		Static Maximum plus water-hammer	720*
12.	Length Pressure Conduit, feet—		
	10′0″ diameter concrete-lined tunnel in rock		24,900
	8′0″ diameter steel interlined section in rock		1,000
	8′0″ diameter concrete-encased steel pipe		1,080
	Total		26,980
13.	Maximum permissible tunnel velocity, feet per second		10
14.	Maximum permissible velocity in 8′0″ diameter section, feet per second		15.6
15.	Cross-sectional area of tunnel, square feet		78.5
16.	Cross-sectional area of 8′0″ dia. section, square feet		50.3
17.	Maximum permissible discharge, cubic feet per second		785
18.	Kutter's n for concrete-lined conduit		0.0125
19.	Friction head loss at 730 cfs, feet		58
20.	Elevation center line of distributor, feet		892
21.	Pressure-conduit valves—Electric Motor-Operated Sector Gear Drive		
	Wicket Diameter, Inches—1 Main Valve		90
	1 Auxiliary Valve		90
	Manufacturer—Newport News Shipbuilding & Dry Dock Company		
	Closing and Opening time—300 seconds		

*For turbine runaway with wicket gates stuck in full-open position.

TABLE 2.—(*Continued*)

22.	Turbine Rating, H.P. at 474 mean net head at point of best efficiency	36,000
	Maximum permissible output, horsepower	41,000
	Draft head, feet	1.3.
	Francis type—Specific speed at rating	26
	Turbine runner, inlet dia., inches	97⅞
	discharge diameter, inches	73.5
	At center line of Distributor—inches	97⅞
23	Normal Operating Speed—RPM	300
24.	Maximum Transient Speed—RPM	610*
25.	Turbine Manufacturer—Newport News Shipbuilding & Dry Dock Company	
26.	Governor Manufacturer—Woodward Governor Company	
27.	Governor, Opening Time, Seconds	200
28.	Governor, Closing Time, Seconds	4
29.	Governor, Gate Limit Operating Time, Seconds	300
30.	Pressure Regulator Capacity—Full turbine discharge	
31.	Pressure Regulator Closing Time, Seconds	200
32.	Pressure Regulator Throat Diameter, Inches	39¾
33.	Pressure Regulator Manufacturer—Newport News Shipbuilding & Dry Dock Company	
34.	Draft-tube type, Elbow—Scroll Case—Cast Steel	
35.	Generator Rating, kva—31,250; Power Factor—0.80	
	Voltage—13,800; Frequency—60 cycles	
	115% normal rating, kva—36,000	
36.	Thrust Bearing—Spring type mounted above stator	
37.	Generator Manufacturer—General Electric Company	
38.	Generator WR^2—lb. ft. squared—4,000,000	
39.	Synchronizing Manual or Automatic—Manual	
40.	Load Control—Manual	
41.	Station Crane Capacity—tons ..... Main Hook	125
	Auxiliary Hook	30

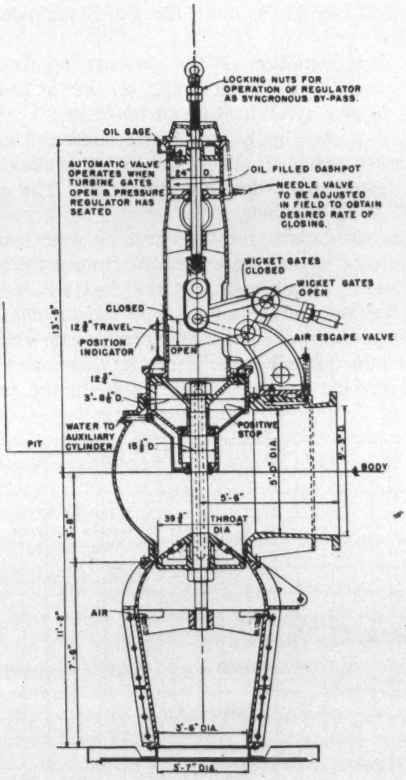
*For turbine runaway with wicket gates stuck in full-open position.

In addition to its own steam plant and hydroelectric system, Central Hudson has interconnections with the Consolidated Edison Co. of New York and the Niagara-Hudson system. The maintenance of system frequency under sudden load changes will be accomplished by the quick-response steam-turbine governors and the large connected rotating inertia (WR^2) of these other plants, and the Neversink power station will be operated at blocked gate near full load for seven or eight hours per day during the working week.

From the hydraulic standpoint, the salient features of the Neversink plant are the result of the long supply tunnel, and the fact that the topography is not favorable to the construction of a surge tank. The topography rises in a direction upstream from the power station at a flat, gradual slope, so that the surge tank at any location sufficiently close to the turbines to afford satisfactory regulation would have to be elevated upon steel tower legs. Almost needless to say, such a design would be prohibitively expensive. But to keep the water-hammer effects within practical and economical limits, the maximum velocity of flow in the tunnel, 10 ft per sec, must be reduced to zero (or for load demand accelerated from zero to 10 fps) very gradually, in not less than 200 seconds. On the other hand, during short-circuited conditions, when the generator is instantaneously disconnected from its electrical load, the water supply must be diverted from the turbine in about 4 seconds, to avoid operating the generating unit at runaway speed for any protracted period.

These two conflicting hydraulic requirements are reconciled by the provision of a governor-operated pressure regulator or relief valve (Fig. 3), directly connected to the gate-operating mechanism of the turbine. By properly proportioning the size of the relay valve ports of the governor oil-pressure system, the turbine gate mechanism is arranged to open through the full range in 200 seconds and close in 4 seconds. But under *rapid* change of load, as fast as the turbine gates are closed, the connecting rod to the pressure regulator opens the relief valve by-pass to accommodate full turbine discharge. By means of an ingenious oil dashpot arrangement, the relief valve then closes slowly, so as to shut off tunnel flow in about 200 seconds. The area of oil ports in the dashpot is made large enough to permit movement of the turbine gates under *gradual* load changes without opening the relief valve.

For routine daily shutdown the unit is very gradually unloaded by the gate limit device on the governor actuator. Mechanically this is effected in the internal mechanism of the governor, by shifting the stop rod which prevents the pilot valve from opening the servomotor piston in response to a speed drop impulse from the flyball. During this operation the pilot valve recenters. The stop-rod linkage and gearing are operated by an electric motor and reduction train, so as to



CROSS-SECTION

39 3/4" PRESSURE REGULATOR

NEVERSINK PROJECT

FIG. 3.

require about 300 seconds to move the gate limit point through the full gate range.

The operating condition of the pressure regulator is checked periodically by tripping the main circuit breaker at any desired gate opening, so as to give a full-load or part-load test.

For closure of the supply tunnel one main and one emergency butterfly valve are provided. These are 90 in. in diameter, operated by means of electric motor-driven sector gears. The operating time of these valves is 300 seconds.

In making calculations for the effect of water-hammer, it was found that the most adverse case resulted from a fairly remote, but entirely conceivable, contingency. If the *pressure regulator* should fail to open after sudden loss of load by the turbine, the size and strength of the connecting rod to the turbine gate shifting ring are sufficient to sustain the full force of the servomotor cylinders, while closure of the turbine gates is slowed down to the prescribed 200

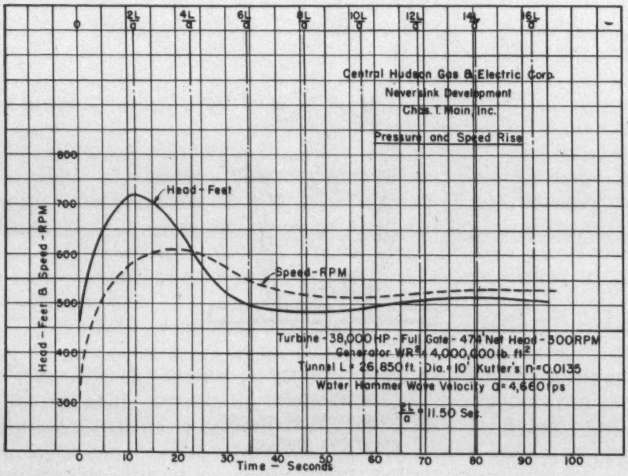

Central Hudson Gas & Electric Corp.
Neversink Development
Chas. T. Main, Inc.
Pressure and Speed Rise
Head - Feet
Speed - RPM
Head - Feet & Speed - RPM
Turbine - 38,000 HP - Full Gate - 471' Net Head - 300 RPM
Generator WR² = 4,000,000 lb. ft²
Tunnel L = 26,850 ft. Dia. = 10' Kutter's n = 0.0135
Water Hammer Wave Velocity a = 4,660 fps
2L/a = 11.50 Sec.
Time - Seconds

FIG. 4.

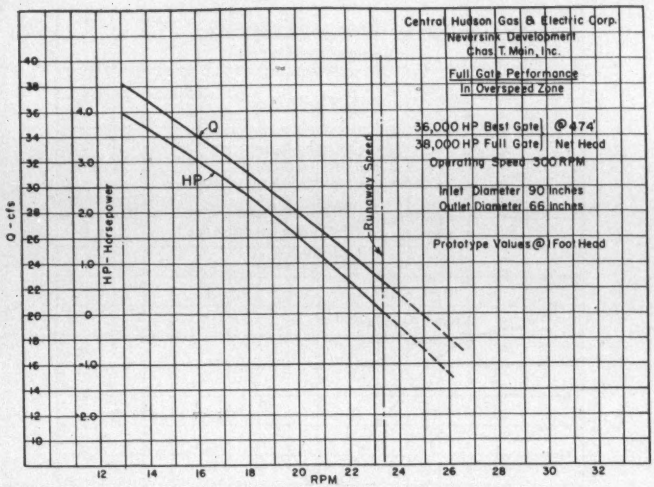


FIG. 5.

seconds by the restriction of oil flow through the dashpot ports of the relief valve or pressure regulator.

However, if the *turbine gates* were to stick in the full-open position, the generating unit would continue to run away until the butterfly valve could be closed. At runaway speeds Francis turbines of this class suffer a very substantial reduction in discharge capacity. This feature operates to reduce flow in the tunnel just as effectively as if one of the butterfly valves were being closed; the condition is further aggravated by the fact that the resulting water-hammer increases the power input of the turbine and thus pyramids the overspeed, all as shown by Figure 4. The rate at which tunnel discharge is arrested depends upon the rate at which the turbine builds up overspeed; that is, upon the rotatory inertia (WR^2) of the generator rotor. The pressure conduit, the turbine and the associated accessories are designed for the water-hammer resulting from this condition. The rotatory inertia (WR^2) of the generator was made large enough

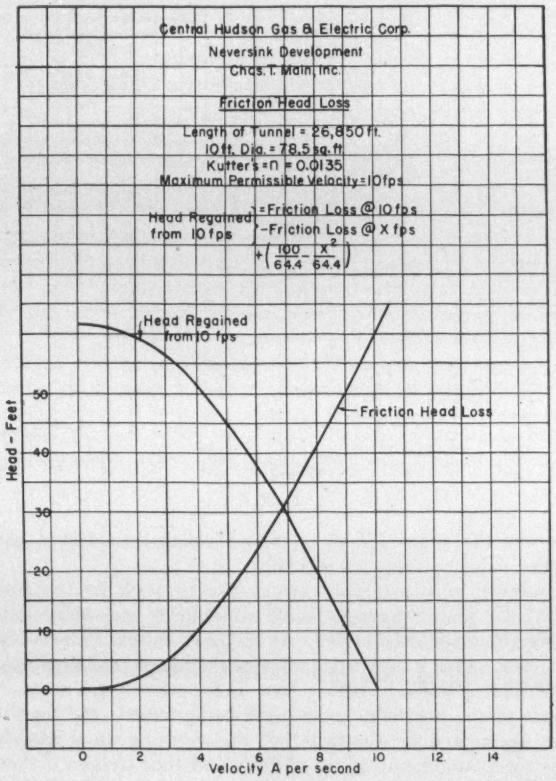


FIG. 6.

to keep water-hammer within economical limits, while the generator and turbine are designed to sustain the resultant runaway speed, which in this case is 610 RPM or over twice the normal operating speed of 300 RPM. It would, however, be wasteful of material to

TABLE 3.—NEVERSINK PROJECT—PRESSURE AND SPEED-RISE COMPUTATION—TURBINE GATES STUCK IN FULL-GATE POSITION

Tunnel Area = 78.5 sq ft L = 26,850 ft
a = 4,660 ft per sec
WR^2 = 4,000,000 lb ft.²

$$\text{Interval } \frac{2L}{a} = \frac{2\times 26{,}850}{4{,}660} = 11.50 \text{ sec} \qquad \Delta H = \frac{a\Delta V}{g} = \frac{4{,}660\Delta V}{32.2} = 145\Delta V$$

$$\text{Work} = \frac{MV^2}{2}$$

$$\text{Aver. HP} \times 550 \times \Delta T = \frac{W}{2g}\left[\frac{4\pi^2R^2(N_1^2-N_2^2)}{3{,}600}\right] \qquad \Delta T = \frac{1.235(N_1^2-N_2^2)}{\text{Av. HP}}$$

Interval	Time (seconds)	V ΔV	$\Delta H = 145\Delta V$	$\Sigma\Delta H$	F regained	$H_0+\Sigma\Delta H+F$	RPM	RPM_1	Q_1	Q	V	HP_1	HP	Average HP	RPM^2	$N_1^2-N_2^2$	ΔT
	0	10.31	0	0	0	474	300	13.8	37.2	810		3.68	38,000		90,000		
		−1.61															
1	11.50	8.70	+233	+233	13	720	582	21.7	25.4	683	8.70	+0.80	+15,500	+26,750	339,000	249,000	11.50
		−2.30															
2	23.00	6.40	+334	+101	35	610	608	24.6	20.4	504	6.42	−0.56	− 8,440	+ 3,530	369,000	33,000	11.50
		−0.57															
3	34.50	5.83	+ 83	− 18	39	495	548	24.6	20.4	467	5.81	−0.57	− 6,280	− 7,360	300,000	69,000	11.50
		+0.31															
4	46.00	6.14	− 45	− 27	36	483	518	23.6	22.2	488	6.19	−0.05	− 530	− 3,405	268,200	31,800	11.50
		+0.33															
5	57.50	6.47	− 48	− 21	34	487	516	23.4	22.55	499	6.36	0	0	− 265	265,725	2,475	11.50
		+0.10															
6	69.00	6.57	− 15	+ 6	32	512	523	23.10	22.95	518	6.60	+0.15	+ 1,730	+ 865	273,800	8,100	11.50
		−0.10															
7	80.50	6.47	+ 15	+ 9	33	516	532	23.40	22.50	510	6.49	0	0	+ 865	281,900	8,100	11.50
		−0.05															
8	92.00	6.52	+ 7	− 2	33	505	529	23.50	22.30	502	6.44	−0.05	− 568	− 284	279,250	2,650	11.50

design the generating unit and supporting structure to sustain this very infrequent overspeed for any protracted interval without some evidence of vibration. All that is justified in such a case is to stipulate that the mechanism have a suitable margin against failure. Accordingly, during emergency shutdown under short-circuited conditions, the governor closure is set at the short time of 4 sec. During the early stages of the design, consideration was given to the possibility of employing an impulse-type turbine, very largely to avoid the water-hammer associated with the overspeed discharge reduction characteristic of the Francis type. This alternate would afford a sizeable reduction in water-hammer; but the available head in this case was too small in proportion to the power output and, even with two nozzles, the jets became excessively large and unwieldy.

Among the interesting features of the Neversink design are (1) provision for removal of the turbine runner from below, (2) the method of erecting the generator rotor, (3) the extensive use of stainless steel in those areas of the turbine which are most susceptible to cavitation, (4) the use of direct-connected cubicle-type switchgear and (5) the auxiliary by-pass system and energy-dissipating chamber.

For the higher-head Francis installations, in which the runner diameter is comparatively small in relation to the power output, it is feasible to construct the upper portion of the draft tube of heavy plate steel entirely, without lateral support from the concrete as delineated in the turbine cross-section, Figure 7. The great advantage of this design is to permit removal of the turbine runner, lower curb plate and wicket gates entirely from below, without dismantling the generator. This is accomplished by unbolting and setting aside the two halves comprising the draft tube and lowering the turbine runner, by means of a special threaded-rod erection device, to a series of heavy pipe rollers, which are supported by rails embedded in the concrete of the basement floor. The runner may then be moved under the hatches in the turbine- and generator-room floors and lifted to the generator floor, if desired, by the power-station crane.

In the normal operating position, the steel upper portion of the draft tube affords additional support to the scroll case by means of jacks, which are distributed about the periphery of the tube at the floor level. After the jacks have been extended to absorb this load,

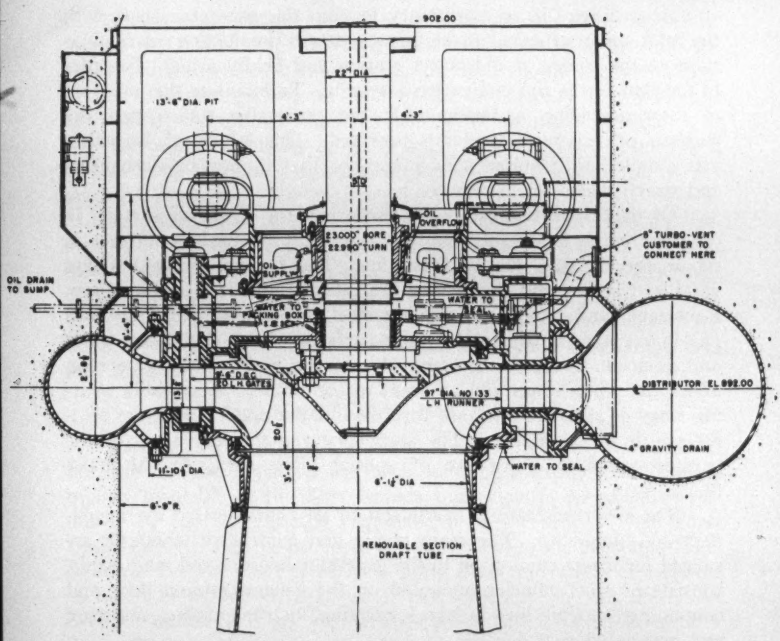


FIG. 7.—CROSS-SECTION OF HYDRAULIC TURBINE—NEVERSINK PROJECT.
(41,000 HP; 300 RPM; 474 Feet Net Head; 36,000 HP at Best Efficiency)

final water-tight sealing of the draft tube at the bottom is effected by a flexible gasket and retainer ring with appropriate tightening studs.

The method of erection adopted for the generator rotor was dictated by the limited capacity of the highway bridges between the railroad siding of the New York, Ontario and Western Railroad at South Fallsburg, N.Y., and the site of construction at Grahamsville. The maximum permissible weight of the largest single piece is 35 tons, while the weight of the completed rotor is 125 tons. The weight of rotor with the so-called floating rim laminations, but without pole-pieces, is 60 tons.

Accordingly, it was necessary to ship the generator shaft with the rotor spider attached at the factory, attach the floating rim laminations to the spider at the power station and finally attach the poles to the slots in the rim lamination assembly. To facilitate this program of rotor assembly, a demountable and removable rotor-supporting pedestal of structural steel was provided. This temporary structure was detailed with bolted connections, so that it may be dismantled and stored when not in service.

Of particular interest is the extensive use of stainless steel, in order to reduce to the minimum the possibility of machine outages to repair the damage due to cavitation. The turbine runner, wicket gates and stems, and throat ring are integral stainless-steel castings. Renewable and removable stainless-steel facing plates are provided (a) in the head cover on the lower surfaces, above the wicket gates and adjacent to the runner, and (b) on the lower wicket-gate ring, under the guide vanes and adjacent to the runner. Renewable wearing rings of stainless steel are furnished at the upper and lower sealing points of the runner. The stationary and movable seats of the pressure-regulator valve are of special alloy steel, ASTM A198 Grade A.

The electrical features of the station are characterized by ruggedness and simplicity. The main power and control switchboard, arranged for direct connection to the generator housing and main leads, consists of steel cubicles, mounted on the generator-room floor and containing the main bus, breakers, relaying, instrumentation, metering and associated gear.

The neutral switchgear, likewise of steel-cubicle construction, is mounted upon the turbine-room floor and arranged for direct connection to the neutral leads.

The architectural design of the power station was prepared by the office of Thomas Keally, New York, and is arranged to conform generally with the buildings of the New York water-supply system.

Still another unusual feature of the Neversink plant is that no water is anywhere visible outside the building. The discharge from the turbine enters an underground chamber of reinforced-concrete construction and thence proceeds through a 10-foot diameter concrete conduit underground to Rondout Reservoir. The hydraulic design of

the tailrace chamber and conduit was verified at the Alden Hydraulic Laboratory of the Worcester Polytechnic Institute, to insure that the entire tailrace structure functions as an open conduit under all conditions of discharge. An air vent of liberal capacity is provided in the roof of the tailrace chamber just below the power station.

To insure continuity of water supply to the city of New York in the event that the hydraulic turbine is out of service for repairs or any other reason, an auxiliary by-pass line is provided, capable of discharging 385 cfs under the available head. This auxiliary line, located in the turbine-room basement, is controlled by two electric motor-driven cone valves in series. The kinetic energy of discharge is dissipated in a cylindrical chamber of reinforced-concrete, incorporated in the tailrace structure. After dissipation is accomplished, the water discharges over a weir crest above the dissipation chamber and into the tailrace chamber.

The East Branch Power Station

Just as in the case of the Neversink development, the mode of operation of the Pepacton Reservoir and the intensity and duration of flow available at the East Branch tunnel outlet are dictated primarily by the water-supply requirements of the city of New York. Under the terms of the proposed contract between the Rockland Light & Power Co. and the city of New York, Rockland would be required to take 314 million cu ft of water per week and pay for the excess over 8.1 billion cu ft per year at the rate of $17.50 per million cu ft. The utility would also pay for water used in excess of the aforesaid 314 million cu ft per week at the rate of $17.50. Accordingly, the Rockland plant is adapted to operate primarily on base load service, 24 hours per day, 5 days per week, as indicated by the power-duration curve, Figure 8.

The pertinent physical features of the project are given in Table 4.

The Rockland Light & Power Co. is also the owner of steam and hydroelectric generating plants, and again, in this case, the quick-response steam-turbine governors and the WR^2 of the interconnected plants contribute toward maintenance of the system frequency.

But between the Neversink and Rockland plants there are two significant differences: the length of the East Branch tunnel is 25

TABLE 4.—PERTINENT PHYSICAL DATA—EAST BRANCH POWER STATION

1.	Name of Power Company		Rockland Light & Power Company
2.	Name of Project		East Branch Tunnel
3.	Name of River		East Branch of Delaware River
4.	Consulting Engineers		Chas. T. Main, Inc.
5.	Designing Engineers		Chas. T. Main, Inc., and New York City Board of Water Supply as part of the Delaware Water System
6.	Project Started		August, 1949
7.	Initial Operation		1954
8.	Dam, type—Earth Embankment	Maximum height, feet	204
		Crest length, feet	2,450
9.	Headwater, feet	Extreme Maximum	1,285
		Normal Maximum	1,280
		Mean (50%)	1,270
		Minimum	1,204
	(Can be drawn to 1,150; sill at 1,143)		
10.	Tailwater elevation, feet		840
11.	Heads, feet	Static Maximum	445
		Mean Net	330
		Minimum	265
		Static Maximum Plus Water-Hammer	650
12.	Length Pressure Conduit, feet		
	11′4″ diameter concrete-lined tunnel in rock		131,355
	9′6″ diameter concrete-encased steel pipe		810
	Total		132,165
13.	Tunnel velocity at full load, feet per second		7
14.	Tunnel velocity at 9′6″ diameter section, feet per sec.		10
15.	Cross-sectional Area of tunnel, square feet		101
16.	Cross-sectional Area 9′6″ diameter section, sq. feet		71
17.	Full-load discharge, cubic feet per second		707
18.	Kutter's n for concrete-lined conduit		
		For surge-tank stability	0.010
		For surge-tank demand	0.013
		For surge-tank rejection	0.0115
		For turbine head computations	0.012
19.	Friction head loss at 707 cfs, feet		
		($n = 0.012$) ($R = 2.83$)	100
20.	Surge-tank dimensions, feet		
		Tank diameter, feet	40
		Riser diameter, feet	10
		Lower Riser diameter, feet	11.33
		Top Elevation	1,325
		Bottom Elevation	1,050

TABLE 4.—(*Continued*)

	Type of Port, Bell-mouth, diverging upward	
	Port Area—square feet	6.00
	Port Coëfficient—Demand	0.94
	Port Coëfficient—Rejection	0.70
21.	Elevation center line of distributor, feet	845
22.	Pressure Conduit Valve—Electric Motor-Operated Sector	
	Gear Drive, Wicket Diameter, Inches	90
	Opening and Closing Time, Seconds	10
	Manufacturer (not yet awarded)	
23.	Turbine Data	
	Rating—Horsepower output at point of best efficiency, 330 feet net head	25,000
	Horsepower desirable at 265 feet net head	20,000
	Runner Discharge Diameter—inches	74
	Draft head, feet	3.3
	Normal Operating Speed, RPM	327
	Speed Full Load Off, RPM	420
	Runaway Speed, 330 feet head, RPM	600
	Specific Speed 25,000 HP, 330 feet head	36.8
	Manufacturer (not yet awarded)	
24.	Governor Manufacturer (not yet awarded)	
25.	Governor, Opening Time, Seconds	5
26.	Governor, Closing Time, Seconds	5
27.	Draft-Tube Type	Elbow
28.	Scroll Case	Cast Steel
29.	Generator Rating, kva	22,500
	Power Factor	0.80
	Voltage	13,800
	Frequency	60 cycles
30.	Thrust Bearing, mounted above stator frame	Kingsbury or Spring
31.	Generator Manufacturer (not yet awarded)	
32.	Generator WR^2—lb. ft. squared	3,000,000
33.	Synchronizing, Manual or Automatic Load	Automatic
34.	Load Control	Automatic

miles, as compared with 5 miles for Neversink; and secondly, the steep topography at East Branch affords an excellent location for a surge tank, excavated in the solid rock hillside in close proximity to the power station.

If the attempt were made to dispense with the East Branch surge tank, we should find (Figure 9) that the transient speed (for the

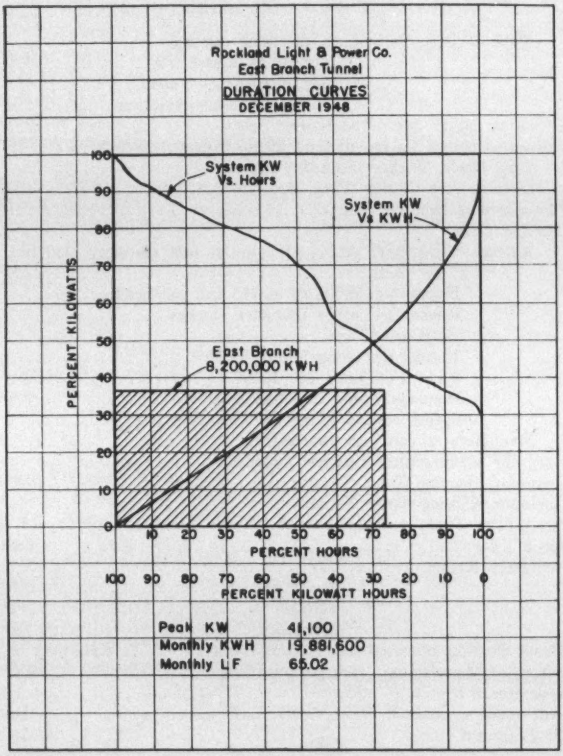


FIG. 8.

emergency condition of turbine gates stuck in the full-open position) would be between 800 and 900 rpm, as compared with about 600 rpm for Neversink. The respective normal operating speeds are 327 and 300 rpm, while the conventional runaway speed for East Branch, when the surge tank is provided, is 600 rpm. The WR^2 provided is

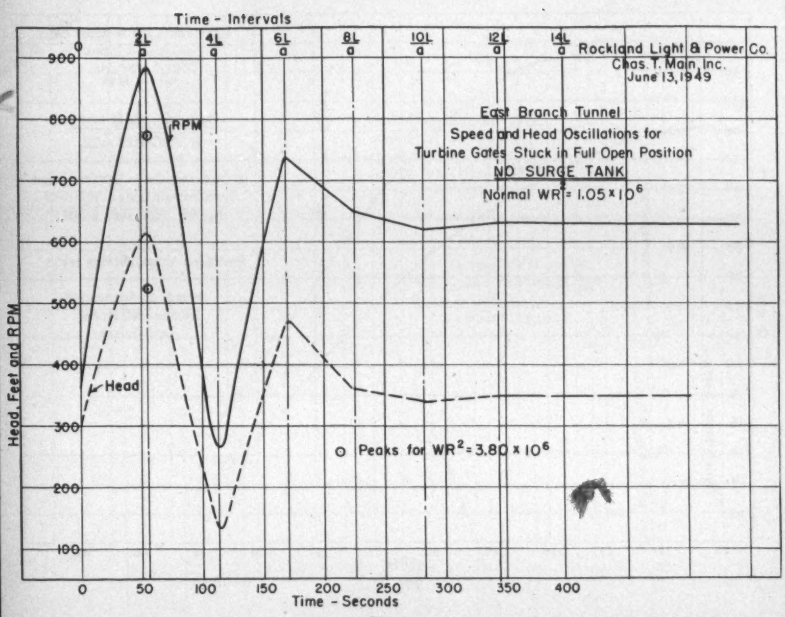

Time - Intervals
Rockland Light & Power Co.
Chas. T. Main, Inc.
June 13, 1949
East Branch Tunnel
Speed and Head Oscillations for
Turbine Gates Stuck in Full Open Position
NO SURGE TANK
Normal WR² = 1.05 x 10⁶
RPM
Head
O Peaks for WR² = 3.80 x 10⁶
Head, Feet and RPM
Time - Seconds

FIG. 9.

4,000,000 lb. ft.^{2} for Neversink and 3,000,000 lb. ft.^{2} for East Branch. Obviously, to design the East Branch generator rotors for 800 rpm instead of 600 rpm would involve a marked increase in generator cost.

Furthermore, because of the much lower net head at East Branch (330 against 474 ft), the size of the necessary pressure regulator would be 25% larger than for Neversink, the discharge being about the same in each case. In addition to the cost of the pressure regulator proper, there is involved a substantial expense for the corresponding concrete substructure and energy-dissipating chamber. With a surge tank no pressure regulator is required.

Without a surge tank at East Branch the governor opening time

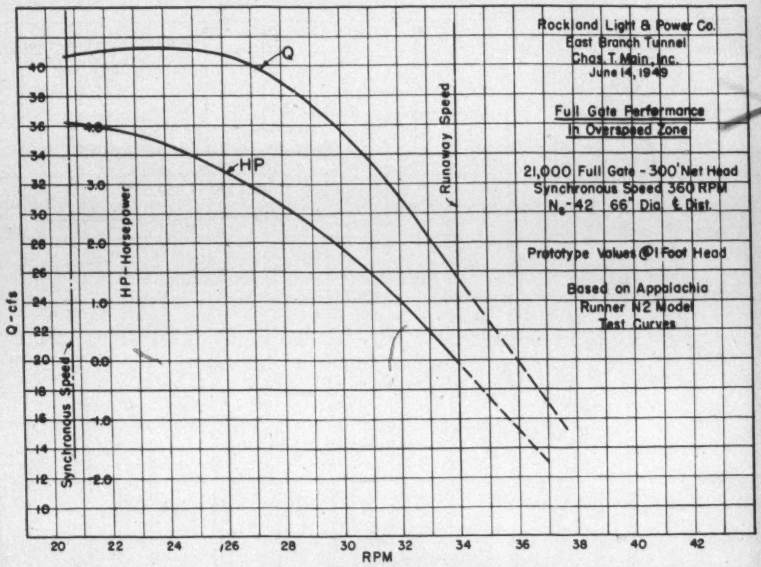


FIG. 10.

would have been in the order of 800 sec, as compared with 5 sec when the tank is installed. With the surge tank, load can be absorbed at the rate of 18,000/5 = 3,600 KW per sec, as compared with 18,000/800 = 23 KW per sec without the tank. This vastly increased rapidity of load absorption obviates the expense of carrying spinning reserve, to hold load increments until the 25-mile tunnel has had time to accelerate. For Neversink the rate of load absorption is 25,000/200 = 125 KW per sec; but the 5-mile tunnel requires much less time to accelerate and consequently the spinning reserve required is proportionately less.

On the basis of comparative cost estimates, reflecting the above considerations, installation of the surge tank was found to be warranted economically.

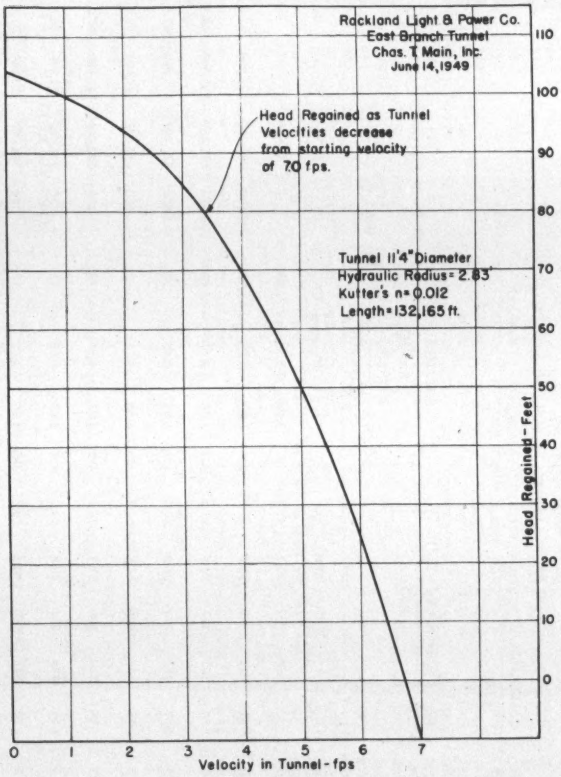


FIG. 11.

In addition to the aforementioned factors, the installation of the surge tank permits the tunnel flow to be shut off in 5 sec, as compared with 5 min for Neversink. This has insurance value in the event of an emergency in the power station.

TABLE 5.—EAST BRANCH PROJECT—IF NO SURGE TANK WERE PROVIDED—PRESSURE AND SPEED-RISE COMPUTATION—TURBINE GATES STUCK IN FULL-GATE POSITION

Tunnel Area = 101 sq ft L = 132,165 ft

a = 4,660 ft per sec

WR^2 = 1,050,000 lb. ft.^{2} and 3,800,000 lb. ft.^{2}

Interval $\frac{2L}{a} = \frac{2\times132{,}165}{4{,}660} = 56.7$ sec $\Delta H = \frac{a\Delta V}{g} = \frac{4{,}660\Delta V}{32.2} = 145\Delta V$

Work $= \frac{MV^2}{2}$

Aver. HP $\times$ 550 $\times$ $\Delta T = \frac{W}{2g}\left[\frac{4\pi^2R^2(N_1^2-N_2^2)}{3{,}600}\right]$ or $\Delta T = \frac{0.323(N_1^2-N_2^2)}{\text{Av. HP}}$ for $WR^2 = 1.05\times10^6$

$\Delta T = \frac{1.175(N_1^2-N_2^2)}{\text{Av. HP}}$ for $WR^2 = 3.80\times10^6$

Interval	Time (seconds)	V ΔV	$\Delta H = 145\Delta V$	$\Sigma\Delta H$	F regained	$H_0+\Sigma\Delta H+F$	RPM	RPM_1	Q_1	Q	V	HP_1	HP	Average HP	RPM^2	$N_1^2-N_2^2$	ΔT
						(a) for WR^2 = 1.05 X 10^6											
0	0	7.00	0	0	0	300	360	20.7	40.7	707	7.00	+4.04	+21,000	—	129,600	—	—
		−1.85															
1	56.7	+5.15	+268	+268	+46	614	884	35.5	21.2	526	5.20	−0.90	−13,700	+3,650	781,000	651,000	57.5
		−0.32															
2	113.4	+4.83	+ 46	−222	+54	132	263	22.9	41.2	475	4.70	+3.85	+ 5,850	−3,925	70,000	711,000	58.5
		+0.65															
3	170.1	+5.48	− 94	+128	+39	467	735	34.0	25.6	555	5.48	−0.05	— 505	+2,670	541,000	471,000	57.5
		−0.90															
4	226.8	+4.58	+130	+ 2	+58	360	650	34.2	24.8	470	4.64	−0.12	— 820	— 663	424,000	117,000	57.5
		+0.10															
5	283.5	+4.68	− 15	− 17	+56	339	620	33.7	26.2	482	4.75	+0.06	+ 360	− 230	383,000	41,000	57.5
		+0.15															
6	340.2	+4.83	− 22	− 5	+53	348	630	33.8	26.2	490	4.83	−0.02	— 130	+ 115	404,000	21,000	58.8
		+0.07															
7	396.9	+4.90	− 10	− 5	+53	348	628	33.8	26.2	490	4.90	−0.02	— 130	− 130	384,000	20,000	57.5
						(b) for WR^2 = 3.80 X 10^6											
0	0	7.00	0	0	0	300	360	20.7	40.7	707	7.00	+4.04	+21,000	—	129,600	—	—
		−1.30															
1	56.7	+5.70	+188	+188	+33	521	775	34.0	25.40	577	5.70	−0.10	— 1,190	+9,905	600,000	470,000	56.1

TABLE 6.—EAST BRANCH DEVELOPMENT, DIFFERENTIAL SURGE TANK—25,000-HP LOAD REJECTION; V = 7 FPS

Headwater Elev., 1,285 (Extreme Maximum)
Tailwater Elev., 840 (Rondout Reservoir)
Kutter's n = 0.0115 (Rejection)
L = 132,165 ft.; Dia. = 11′4″;
Area = 101 sf; Hyd. Rad. = 2.83′
Head Loss @ 7 fps = 132×0.7 = 93 ft
C in CV^2 = 93/49 = 1.90 (Intake to tank)

$$\Delta h = \frac{L}{g}\frac{\Delta V}{\Delta t} \qquad \Delta V = \frac{32.2\,\Delta t\,\Delta h}{132{,}165}$$

Penstock Head Loss:
L = 370′ @ 11′4″; 800′ @ 9′6″; Aver. Area = 80.2 sf; R = 2.50
n = 0.0115; Head Loss = 1.17×1.3 = 1.52; V = 8.8 fps;
C in CV^2 = 1.52/77.4 = 0.02

Port Area = 6.00 sf gross
Net Port Area (Rejection) = 6.00×0.70 = 4.20 sf
$Q = 8.02 \times 4.20\sqrt{H} = 33.7\sqrt{H}$

Tank Diameter = 40′; Area = 1,255 sf
Riser Diameter = 10′; Area = 79 sf
Net Tank Area = 1,176 sf
Gov. Time 8 Sec (100% gate)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
							Turbine						Friction		Aver.		Conduit	Vol. thru	Columns
Time (sec)	W. s. elev. tank (ft)	W. s. elev. riser (ft)	Flow to tank (cfs)	Vol. to tank in dt (cf)	Flow to riser (cfs)	Vol. to riser in dt (cf)	Net head (ft)	Gate (%)	Discharge (cfs)	Vol. in dt (cf)	Horsepower	Head on conduit (ft)	loss—conduit (ft)	Accel. head (ft)	accel. head (ft)	Conduit velocity (fps)	discharge (cfs)	cond. in dt (cf)	(5)+(7)+(11) (cf)
0	1192.00	1192.00	0	0	0	0	350.48	63	707	0	25200	93.00	93.00	0	0	7.00	707	0	0
1.00	1192.01	1192.98	33	16	154	77	351.50	46	521	614	18000	92.02	93.00	0.98	0.49	7.00	707	707	707
2.00	1192.05	1195.60	64	48	258	207	355.04	33	385	452	12200	89.40	93.00	3.60	2.29	7.00	707	707	707
3.00	1192.12	1199.50	92	78	358	308	359.33	21	257	321	7000	85.50	93.00	7.50	5.55	7.00	707	707	707
4.00	1192.21	1204.75	120	106	470	414	364.70	10	117	187	3000	80.25	93.00	12.75	10.13	7.00	707	707	707
5.00	1192.33	1211.26	147	134	560	515	—	0	0	58	0	73.74	93.00	19.26	16.05	7.00	707	707	707
7.00	1192.62	1224.86	192	340	515	1074	—	—	—	—	—	60.14	93.00	32.86	26.06	7.00	707	1414	1414
10.00	1193.17	1243.46	239	645	465	1470	—	—	—	—	—	41.54	92.50	50.96	41.91	6.97	705	2115	2115
15.00	1194.31	1270.50	295	1340	390	2135	—	—	—	—	—	14.50	90.20	75.70	63.33	6.89	695	3475	3475
20.00	1195.65	1293.80	335	1575	347	1842	—	—	—	—	—	— 8.80	87.20	96.00	85.85	6.78	685	3425	3417
25.00	1197.15	1314.45	365	1765	305	1630	—	—	—	—	—	—29.45	84.00	113.45	104.72	6.65	672	3395	3395
26.00	1197.46	1318.28	370	368	300	303	*Riser Crest at Elevation 1,318*					—33.28	83.00	116.28	100.14	6.62	667	670	670
30.00	1199.71	1319.22	369	1476	284	1168	$Q = 210 \times 1.22^{3/2} = 284$ cfs					—34.22	80.30	114.52	115.40	6.50	656	2644	2644
100.00	1233.91	1318.91	311	23800	182	16350	$Q = 210 \times 0.91^{3/2} = 182$ cfs					—33.91	44.70	78.61	96.57	4.85	490	40200	40200
175.00	1261.31	1318.66	256	21200	111	11000	$Q = 210 \times 0.66^{3/2} = 111$ cfs					—33.66	24.80	58.46	68.53	3.61	365	32200	32200
250.00	1281.46	1318.44	206	17300	60	6400	$Q = 210 \times 0.44^{3/2} = 60$ cfs					—33.44	13.25	46.69	52.58	2.64	267	23700	23700
325.00	1295.91	1318.27	159	13750	27	3250	$Q = 210 \times 0.27^{3/2} = 27$ cfs					—33.27	6.50	39.77	43.23	1.85	187	17000	17000
400.00	1305.61	1318.00	119	10400	0	1000	$Q = 0$					—33.00	2.50	35.50	37.63	1.16	117	11400	11400
475.00	1313.50	1316.50	59	6670	—3	—120	—	—	—	—	—	—31.50	0.60	32.10	33.80	0.56	57	6550	6550
550.00	1316.50	1316.50	4	2370	—3	—225	—	—	—	—	—	—31.00	0.00	31.00	31.55	0	0	2140	2140

TABLE 7.—EAST BRANCH DEVELOPMENT, DIFFERENTIAL SURGE TANK—LOAD DEMAND FROM 2 TO 7 FPS

Turbine Gates Blocked at 83%—Load Control Limits Power Output to 20,000 HP

Headwater Elevation, 1,204
Tailwater Elevation, 840
Kutter's $n = 0.013$
Head Loss at 7.0 fps $= 132 \times 0.9 = 119$ ft
C in $CV^2 = 119/49 = 2.43$ (Demand)

$L = 132{,}165$ ft
Area $= 101$ sf
Hydr. Rad. $= 2.83$ ft
Penstock Load Loss $= 0.025V^2$
Area $= 80.2$ sf; $R = 2.50$

$$\Delta V = \frac{32.2\,\Delta t\,\Delta h}{132{,}165}$$

Port Area $= 6.00 \times 0.94 = 5.64$ sf
$Q = 45.2\sqrt{H}$

Gross Area of Tank $= 1{,}255$ sf
Riser Area $= 79$ sf
Net Area of Tank $= 1{,}176$ sf

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
							Turbine												
Time (sec)	W. s. elev. tank (ft)	W. s. elev. riser (ft)	Flow from tank (cfs)	Vol. from tank in dt (cf)	Flow from riser (cfs)	Vol. from riser in dt (cf)	Net head (ft)	Gate (%)	Discharge (cfs)	Vol. in dt (cf)	Horsepower	Head on conduit (ft)	Friction loss—conduit (ft)	Accel. head (ft)	Aver. accel. head (ft)	Conduit velocity (fps)	Conduit discharge (cfs)	Vol. thru cond. in dt (cf)	Columns (11) − (5) − (7) (cf)
0	1194.28	1194.28	0	0	0	0	354.13	17	202	0	5000	9.72	9.72	0	0	2.00	202	0	0
5	1194.01	1186.36	125	312	250	625	346.00	52	577	1950	20000	17.64	9.72	7.92	3.96	2.00	202	1010	1013
25	1190.26	1140.06	320	4450	116	3660	298.50	63	650	12270	20000	63.94	11.76	52.18	30.05	2.15	217	4190	4160
50	1182.78	1110.00	384	8800	73	2370	268.00	76	707	16850	19000	94.00	15.20	78.80	65.49	2.55	258	5940	5680
75	1174.46	1098.00	396	9775	3	948	256.00	80	707	17650	18200	106.00	21.85	84.15	81.48	3.05	308	7080	6927
100	1166.39	1101.00	365	9510	—22	—237	259.00	79	707	17650	18600	103.00	31.60	71.40	77.78	3.53	357	8300	8377
125	1159.07	1107.00	326	8620	—16	—474	265.00	77	707	17650	19000	97.00	40.00	57.00	64.20	3.92	396	9400	9504
150	1152.47	1110.00	294	7750	— 4	—237	268.00	76	707	17650	19200	94.00	43.90	50.10	53.55	4.25	429	10300	10137
175	1146.42	1112.00	265	7100	— 9	—158	270.00	75	707	17650	19300	94.00	49.20	44.80	47.45	4.54	458	11100	10700
200	1141.12	1114.00	235	6250	— 4	—158	272.00	75	707	17650	19500	90.00	56.00	34.00	39.40	4.78	482	11720	11558
225	1136.40	1115.00	209	5550	— 2	— 79	273.00	75	707	17650	19800	89.00	60.80	28.20	31.10	4.97	502	12290	12179
250	1132.13	1114.00	193	5020	9	79	272.00	75	707	17650	19300	90.00	63.50	26.50	27.35	5.13	518	12700	12551
275	1128.21	1113.00	175	4600	3	79	271.00	75	707	17650	19500	91.00	67.50	23.50	25.00	5.28	533	13180	13129
300	1124.64	1112.00	160	4200	9	79	270.00	76	707	17650	19300	92.00	72.20	19.80	21.65	5.41	548	13500	13371
400	1112.69	1105.00	125	14200	2	554	263.00	78	707	70700	18900	99.00	81.70	17.30	18.55	5.86	592	57000	55946
500	1104.41	1102.11	70	9755	3	330	260.00	78	707	70700	18600	101.89	92.50	9.39	13.35	6.19	627	61000	60945
600	1099.09	1097.61	55	6250	4	355	255.50	80	707	70700	17300	106.39	100.50	5.89	7.64	6.38	646	63700	64095

TABLE 8.—EAST BRANCH DEVELOPMENT, DIFFERENTIAL SURGE TANK—LOAD DEMAND 0 TO 7.0 FPS

Turbine Gates Blocked at 83%—Governor Flyball Closes Gates at 21,000 HP

Headwater Elevation, 1,204
Tailwater Elevation, 840
Kutter's $n = 0.013$
Head Loss at 7.0 fps $= 132 \times 0.9 = 119$ ft
C in $CV^2 = 719/49 = 2.43$ (Demand)

$L = 132{,}165$ ft
Area $= 101$ sf
Hydr. Rad. $= 2.83$ ft
Penstock Hd. Loss $= 1{,}025V^2$
Area $= 80.2$ sf; $R = 2.50$

$$\Delta V = \frac{32.2\,\Delta t\,\Delta h}{132{,}165}$$

Port Area $= 6.00 \times 0.94 = 5.64$ sf.

$$Q = 45.2\sqrt{H}$$

Gross Area of Tank $= 1{,}255$ sf
Riser Area $= 79$ sf
Net Area of Tank $= 1{,}176$ sf

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
							Turbine												
Time (sec)	W. s. elev. tank (ft)	W. s. elev. riser (ft)	Flow from tank (cfs)	Vol. from tank in dt (cf)	Flow from riser (cfs)	Vol. from riser in dt (cf)	Net head (ft)	Gate (%)	Discharge (cfs)	Vol. in dt (cf)	Horsepower	Head on conduit (ft)	Friction loss—conduit (ft)	Accel. head (ft)	Aver. accel. head (ft)	Conduit velocity (fps)	Conduit discharge (cfs)	Vol. thru cond. in dt (cf)	Columns (14) − (5) − (7) (cf)
0.00	1204.00	1204.00	0	0	0	0	364.00	0	0	0	0	0	0	0	0	0	0	0	0
10.00	1203.07	1180.00	217	1085	379	1895	338.60	54.0	597	2985	21000	24.00	0	24.00	12.00	0.03	3	15	5
20.00	1200.62	1136.50	361	2890	308	3435	295.10	68.0	685	6410	21000	67.50	0	67.50	45.75	0.14	14	85	85
30.00	1197.20	1101.10	443	4020	252	2800	259.45	83.0	735	7100	19000	102.90	0.30	102.60	85.05	0.35	35	250	280
35.00	1195.27	1086.65	471	2285	203	1140	245.15	83.0	707	3605	17000	117.35	0.56	116.79	109.70	0.48	49	210	180
45.00	1191.14	1069.35	502	4870	71	1370	227.85	83.0	670	6890	15000	134.65	1.52	133.13	124.96	0.79	80	650	650
55.00	1186.86	1061.75	507	5050	49	600	220.50	83.0	660	6650	14500	142.25	3.80	138.45	135.79	1.12	113	965	1000
75.00	1178.41	1062.37	488	19960	—49	0	221.00	83.0	660	13200	14500	141.63	8.07	133.56	136.00	1.79	182	2980	3240
100.00	1168.51	1072.00	443	11620	—11	—760	230.50	83.0	680	16700	15300	132.00	15.95	116.05	124.81	2.56	259	5300	5840
125.00	1159.56	1088.00	404	10600	—39	—632	238.50	83.0	695	17200	16500	124.00	24.90	99.10	107.58	3.21	323	7270	7232
150.00	1151.51	1090.00	354	9460	—25	—726	248.50	83.0	710	17700	17700	114.00	34.20	79.80	89.45	3.75	379	8770	9030
175.00	1144.34	1095.00	320	8440	— 7	—395	253.50	83.0	725	17850	18000	109.00	42.90	66.10	72.95	4.20	425	10050	9417
200.00	1137.89	1098.00	284	7550	—12	—237	256.50	83.0	725	17850	18500	106.00	54.60	51.40	58.75	4.56	460	11100	10315
225.00	1132.12	1100.00	256	6750	0	—158	258.50	83.0	735	18300	19000	104.00	57.40	46.60	49.00	4.86	491	11880	11550
250.00	1127.02	1101.00	231	6080	— 6	— 79	259.50	83.0	735	18400	19000	103.00	63.50	39.50	43.05	5.12	516	12600	12326
325.00	1114.27	1100.00	171	15075	8	79	258.50	83.0	735	55000	19000	104.00	80.30	23.70	31.60	5.70	576	41000	39486
400.00	1104.82	1098.00	118	10880	— 4	158	256.50	83.0	730	54900	18500	106.00	90.50	15.50	19.63	6.07	614	44600	43862
500.00	1096.08	1094.00	64	9100	10	316	252.50	83.0	720	72500	18000	110.00	107.00	3.00	9.25	6.30	637	62500	63084

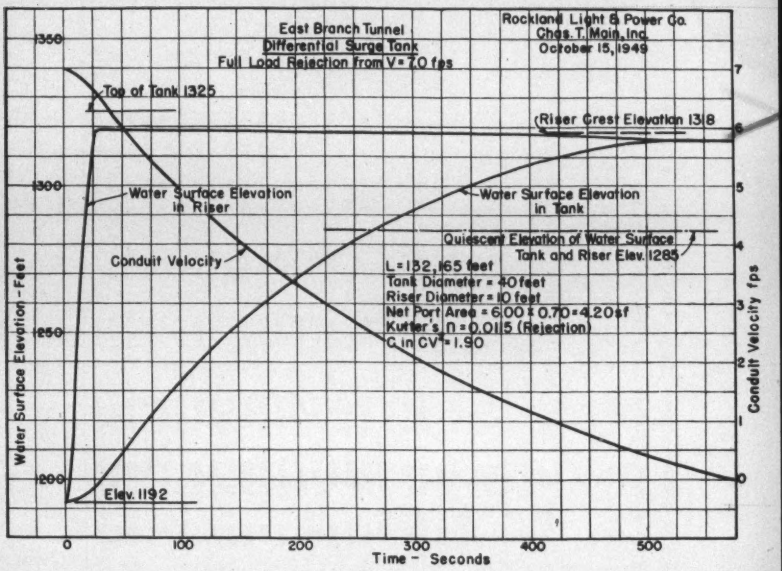


FIG. 12.

The calculated performance curves for the surge tank are given by Figures 12, 13 and 14, from which a distinctive feature is immediately apparent: under load-demand conditions, because of the very heavy damping effect of friction in the 25-mile tunnel, the action of the tank is "dead-beat" rather than oscillatory; that is, after the first quarter-cycle, the calculated water-surface curves become tangent to the quiescent level at Elevation 1,085. In fact, for one particular load demand, from 1 fps to 7 fps, the riser curve shows the ideal "rectangular" action by dropping at once to the quiescent level, Elevation 1,085, and for all practical purposes remaining there.

Because the demand surge is dead beat, and the steady-state gradient for full load drops to Elevation 1,085, no appreciable expense is involved in designing the surge tank for large-load demand.

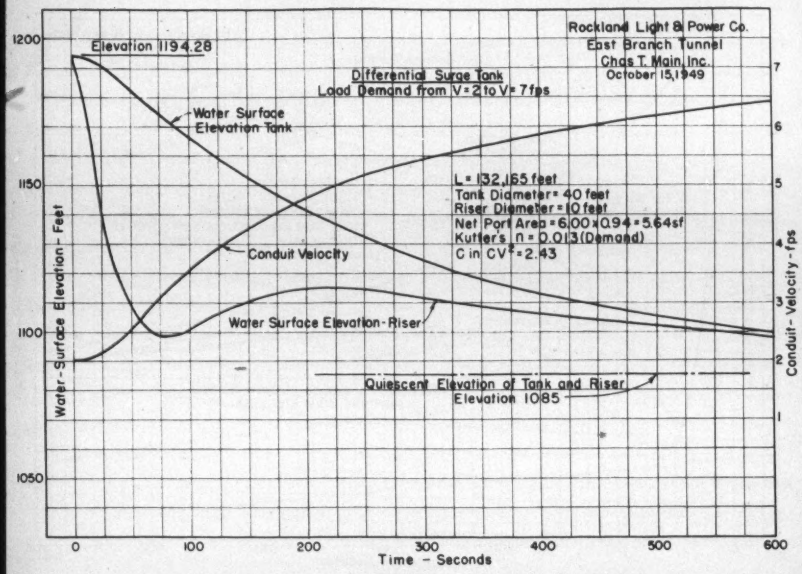


FIG. 13.

As is well known, the large-load demand condition requires a larger net effective port area than the full-load rejection condition. This dual requirement is satisfied very neatly by employing a port of the diverging or bell-mouth type, with the bell-mouth pointing upwards. Laboratory and prototype test results show a value of discharge coëfficient of 0.70 for flow upwards and 0.94 for flow downwards. For the East Branch tank, the coëfficient of 0.94 establishes the limiting value of demand load that can be accommodated without having the water level in the riser drop below the quiescent gradient, Elevation 1,085—namely, a load demand from 1 fps to 7 fps.

For the load demand of 0 fps to 7 fps, the riser drops to about Elevation 1,065. However, this relatively small additional volume for the main or outer tank can be obtained quite inexpensively, since

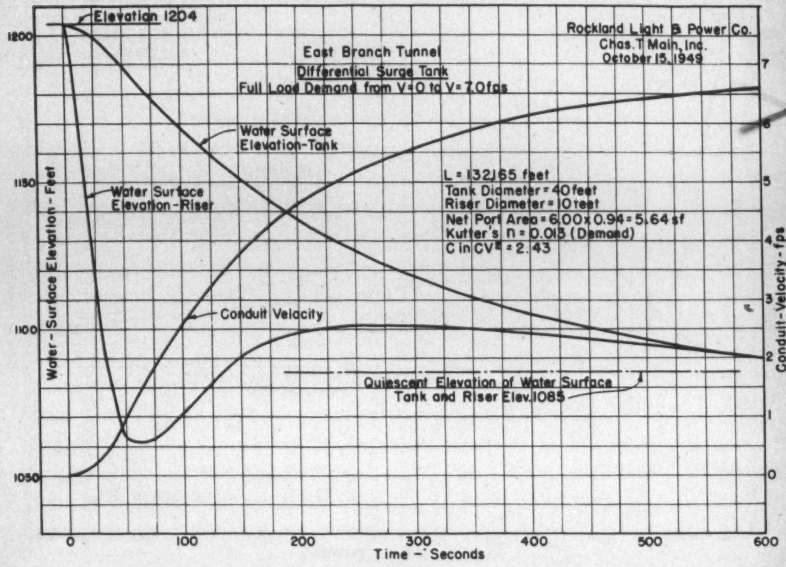


FIG. 14.

excavation for the outer chamber costs about $8.00 per cu yd, as compared with $40.00 per cu yd for the riser shaft (which must be excavated in any case).

In connection with the selection of the differential tank, the question always arises why the central riser pipe is not omitted entirely, since deceleration and acceleration of the tunnel upstream of the tank may be just as well effected by the use of a so-called restricted orifice without any riser.

The answer is to be found in the calculation of water-hammer in the penstock downstream from the surge tank. In those installations in which the calculated port or orifice area is relatively large, the water-hammer reflection at the port (without the riser) is substantially that for the desired open-end condition, and the desired large negative reflection is returned to the turbine gates.

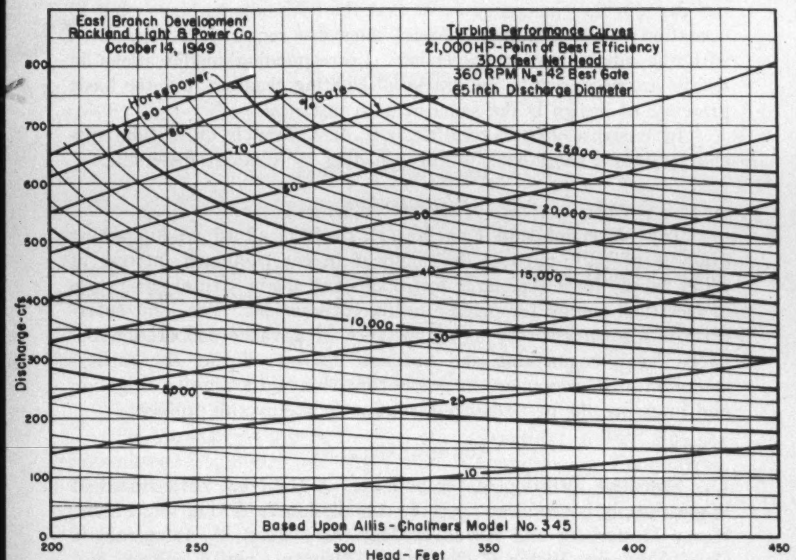


FIG. 15.

However, in cases like East Branch, in which the calculated orifice area is small compared to the riser area, the water-hammer reflection (for the condition with internal riser omitted) is substantially that for the closed-end condition, which tends to aggravate rather than compensate the primary water-hammer, generated at the turbine gates. Accordingly, provision of the internal riser is essential at East Branch to supply the open-end condition and the compensating negative reflections. The physical action can easily be verified by a few intervals of arithmetic integration, the orifice law being applied as a boundary value at the surge tank as well as at the turbine gates.

The East Branch power plant is at present in the preliminary stages of design. Because of the greater volume of water to be handled

per day (in the emergency event that the hydraulic turbine is not in operation), four auxiliary by-pass lines are required, as compared with the single line at Neversink. Corresponding modifications in details are necessary in the energy-dissipating chamber, but the basic principle of design is the same in both instances.

In contrast with Neversink, the East Branch draft tube discharges into a short open tailrace, leading to Rondout Reservoir.

Conclusion

The Neversink and East Branch projects afford an interesting example of multi-purpose development in the combined interest of water supply for a very large metropolis and the incidental generation of electrical energy for private utility corporations. The joint enterprise is also noteworthy as an instance of advance coöperation between legal, engineering and business interests during the earliest inception of development, in ample time to avoid expensive litigation and to assure the best-balanced solution to the overall problem.

Acknowledgment

Executive direction of the activities of the New York Board of Water Supply is exercised by three commissioners, Irving V. A. Huie, Henry Hesterberg and Rufus E. McGahen. John M. Fitzgerald is Chief Engineer, Victor C. Brownson, Deputy Chief Engineer, and Torris Eide, Headquarters Department Engineer.

Mr. O. H. Bundy is Executive Engineer in charge of engineering and construction work on the Neversink power station for the Central Hudson Gas & Electric Corp.; Mr. J. O. Fuchs is Operating Manager.

Mr. F. L. Lovett, Vice-President and General Manager, is in charge of engineering and construction work on the East Branch power station for the Rockland Light & Power Co.

Mr. W. F. Uhl is consulting engineer to the two utility companies and President of Chas. T. Main, Inc., designing engineers for the power-station work.

It is desired to acknowledge the substantial assistance received from the above executives in the preparation of this article.

PROCEEDINGS

Sixty-ninth Annual Convention

Poland Spring, Me.

September 18-20, 1950

The Sixty-ninth Annual Convention of the New England Water Works Association was held at the Poland Spring House, Poland Spring, Me., on September 18, 19 and 20, 1950.

Monday, September 18

Morning Session

President Sidney S. Anthony in the Chair.

The Annual Reports of the Secretary, Treasurer, Editor, Finance Committee, Committee on Legislation, Committee on Committees, Committee on Technical Program, Committee on Membership and Committee on Reciprocal Relations with the Institution of Water Engineers were presented and accepted.

The following progress reports of technical committees were presented and accepted: Committee on Reinforced Concrete Pressure Pipe, Committee on Laying Cast-Iron Water Mains, Committee on Specifications for Steel Pipe, Committee on Gate Valves, Committee on Fluid Permeability, Committee on Specifications for Cast-Iron Pipe and Fittings, Committee on Rainfall and Yield of Drainage Areas, and Hydrant Specification Committee.

Informal reports were presented by the Committee on Library and Committee on Meter Specifications. All formal reports are printed in this issue of the Journal.

The President declared the polls closed and appointed as tellers John H. Robinson, Emery S. Littlefield and Thomas S. Lawrence.

Upon motion duly made and seconded, it was Voted that the Specifications for Cold-Water Meters — Current Type — Propeller Driven, as published in the December, 1949, Journal of the Asso-

ciation and accepted as tentative by the Executive Committee on February 16, 1950, be adopted as standard specifications of the New England Water Works Association. It was then VOTED that the Committee on Meter Specifications be discharged from further duties and that the committee be given a vote of thanks for the time it has put in.

Secretary Knox announced the election of the following to membership in the Association: John Edward Gahagan, Dept. of Public Works, Norwood, Mass.; Elwood E. Smith, Superintendent, Seekonk Water District, Seekonk, Mass.; Vincent Mascia, General Manager, Wallingford Water District, Wallingford, Conn.; Ervin L. Welch, Town Manager, Mansfield, Mass.; Charles W. Harvey, Assistant Superintendent of Water, New London, Conn.; Ira R. Loring, Superintendent, Onset Fire Dept., Wareham, Mass.; Joseph Christopher Lawler, Jr., Camp, Dresser & McKee, Boston, Mass.; Miguel Tebar Escribano, National Institute of Sanitary Works, Caracas, Venezuela; Arnold G. Carey, Thomas Worcester Co., Melrose, Mass.

Associate Member: M. C. Allan, Water-Works Supplies, Hillsgrove, R. I.

Associate Member Reinstated: Inertol Co., Inc., Paints and Protective Coatings, Newark, N. J.

Corporate Member: Board of Commissioners, Manhasset-Lakeville Water District, Manhasset, N. Y.

Afternoon Session

A paper on "Humor Patented," illustrated with stereopticon slides, was read by Charles G. Richardson, Vice-President, Builders-Providence, Inc., Providence, R. I.

A paper on "New England Dams and Our Water Resources" was read by Richard Martin, Director, State Water Commission, Hartford, Conn.

A paper on "Peak Water-Demand Loads in Water-Supply Systems" was read by William E. Stanley, Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Tuesday, September 19

Morning Session

Superintendents' Round Table. There was a Symposium on Water Meters, including the manufacture, testing and setting of meters. The discussion was led by William B. Duffy, Superintendent, Board of Public Works, North Andover, Mass.

A paper on "The Cost of Operating Construction Equipment" was read by Sherman L. Rogers, Superintendent of Distribution, Water Bureau, Metropolitan District, Hartford, Conn.

Wednesday, September 20

Morning Session

A paper on "Present-Day Uses of Cone-Type Valves" was read by Carl J. Wilcox, Manager, Valve Division, S. Morgan Smith Co., York, Pa.

A paper on "Sanitary Protection of Watersheds—Are We Overdoing It or Underdoing It?" was read by Arthur D. Weston, Consulting Sanitary Engineer, Charles A. Maguire & Associates, Boston, Mass. Prepared discussions were submitted by Warren J. Scott, Director, Bureau of Sanitary Engineering, State Department of Health, Hartford, Conn., and Harold B. Scales, Chemist, Portland Water District, Portland, Me.

Linn H. Enslow, Coördinator, E. J. C. Water Policy Panel, and Editor of Water & Sewage Works, New York, N. Y., read the highlights of a statement addressed to the President's Water Resources Policy Commission and the Congress of the United States, by the Water Policy Panel of the Engineers' Joint Council.

Afternoon Session

A paper on "The Maintenance and Repair of Dams and Other Hydraulic Structures" was read by Bryant L. Hopkins, Engineer, Kennebec Water Power Co., Waterville, Me.

A paper on "Water-Supply Developments in the Other American Republics" was read by Clarence I. Sterling, Jr., Chief Sanitary Engineer, Massachusetts Department of Public Health, Boston, Mass.

A paper on "The Construction of Spherical and Radial-Cone Elevated Water Tanks" was read by J. Edgar Revell, Contracting Engineer, Chicago Bridge & Iron Co., Boston, Mass.

Evening

Through the courtesy of the Water and Sewage Works Manufacturers Association, Inc., a social hour was held in the ball-room of the Poland Spring House, followed by a dinner in the main dining-room of the hotel.

AWARD OF THE DEXTER BRACKETT MEMORIAL MEDAL

PRESIDENT ANTHONY. I shall now introduce Horace L. Clark, who will make the presentation of the Dexter Brackett Memorial Medals to Samuel Jacobson and Marshall S. Wellington together, if they will please step forward.

HORACE L. CLARK. Mr. President, members and guests: As you well know, the Dexter Brackett Memorial Medal is awarded each year to the member whose paper, published in the JOURNAL, was considered to add the most to our knowledge of water-works matters.

Dexter Brackett was a well-known engineer in the water-works field. He was president of the New England Water Works Association in the years 1889 and 1890. He was Editor of the JOURNAL for a number of years. He was with the Boston Water Department and later Chief Engineer of the Metropolitan Water System. His interest in the Association contributed greatly to its high standard.

Since the award was established in 1916, 29 members have received the award.

The Committee this year, consisting of Donald W. Loiselle of the Bridgeport Hydraulic Co., Bridgeport, Conn., John B. Kennedy, General Manager, Norwood, Mass., and the speaker, were of the opinion that the paper written jointly by Dr. Samuel Jacobson and Marshall S. Wellington, published in the June issue of the JOURNAL and entitled "Introduction of Pre-Chlorination of Slow Sand Filters," was the most meritorious paper published in the JOURNAL during 1949.

I believe this is the first time that a paper written jointly has received the award, and the question arose how to divide it. The Executive Committee solved the problem by authorizing two medals.

Both recipients are employed by the New Haven Water Co. Dr. Jacobson is Chemist and Bacteriologist, which position he has held for nine years. He graduated from M.I.T. in 1931 and received his doctor's degree from the same institution in 1935. He was a re-

search assistant at M.I.T. and was formerly employed by the Maryland State Health Department. Mr. Wellington is a Sanitary Engineer and has held this position with the New Haven Water Co. since 1924. Previously he held various positions as a sanitary engineer, including assistant at M.I.T., with Wallace & Tiernan, and with the State Health Department of Pennsylvania.

Gentlemen, it gives me great pleasure to present to you these Dexter Brackett Memorial Medals.

MARSHALL S. WELLINGTON. Mr. Clark, I wish through you to thank the officers of the New England Water Works Association and the members of the Association for conferring this honor upon me and my associate in crime, Dr. Jacobson. I wish to express my deep appreciation and gratitude for your conferring this honor upon me. I am particularly happy to receive it, as through my mother it has come back again into the family of the person to whom it is a memorial. I thank you.

SAMUEL JACOBSON. Thanks ever so much for this very great honor. I am very happy and very grateful. I wish to take this opportunity to express my thanks and appreciation to those people who helped us in the work, our co-workers at the New Haven Water Co., and for the support of the New Haven Water Co. in this research, and also for the stimulating interest of Mr. Edward E. Minor, who was, at the time this study was made, in active charge of the company affairs. I thank you very much.

COMMEMORATIVE AWARD

PRESIDENT ANTHONY. We have another award, the Francis W. Dean Commemorative Award. This Commemorative Award was established last year by the Association in memory of members who have been prominent in the several fields of the water-works profession.

The purpose of the award is to give due recognition to the paper which shall be judged as the next most meritorious to the one which receives the Dexter Brackett Memorial Medal.

The Commemorative Award is made this year in memory of Francis W. Dean, who was an instructor in engineering at Harvard for several years following his graduation from that institution. He was engaged in private consulting-engineering practice in Boston for many years. He became a member of this Association in 1890 and was active in its affairs until the time of his death in 1940. Mr. Dean was the author of six papers published in the JOURNAL relating to pumping-station equipment and operation. In 1928 he was the recipient of the Dexter Brackett Memorial Medal for his paper entitled "Pumping Station Practices."

It gives me great pleasure to make this award to Clarence H. Ahlgren, of Manchester, N. H., for his paper, "Diesel Pumping Unit for Manchester Water Works." Will Mr. Ahlgren please step forward?

Mr. Ahlgren, here is your award, a set of books and a plaque to put on the wall of your office.

CLARENCE H. AHLGREN. I deeply appreciate the honor of receiving this award, Mr. President, particularly since it is the second time it has been given. I accept it in the memory of Francis Dean. It also is a tribute to a man who is here tonight, who is recognized in his field. My paper is the summary of some 17 years of accomplishments by one of the grand men of the Association, whom I have had the pleasure of working under, Mr. Percy Shaw. I thank you.

* * *

PRESIDENT ANTHONY. We also have Twenty-five Year awards

to give to three gentlemen who are not here. They will be sent the certificates in due course. Their names are G. Lewis Covell, Superintendent of the Warren Water District, Warren, Mass., Charles E. Fuller, Manager of the Water, Sewer and Electric Light Department, Wellesley, Mass., and Samuel G. Wylie, Superintendent of the Water Department, Webster, Mass. This award is made to those who have been members of the Association for 25 years and who have served the same municipality for the same number of years. In due course the certificates will be mailed to them.

It now is the time to ask for the report of the Tellers, giving the results of the election—this highly contested election which has been going on for the last several weeks. Mr. John H. Robinson is chairman.

REPORT OF THE TELLERS OF ELECTION

Total number of votes cast: 310 (2 blanks)

For PRESIDENT: Thomas R. Camp	305
For VICE-PRESIDENT: Stanley M. Dore	304
For DIRECTOR: Allan F. McAlary	305
For TREASURER: William P. Melley	306

Respectfully submitted,

(*Signed*) JOHN H. ROBINSON
THOMAS S. LAWRENCE
EMERY S. LITTLEFIELD

PRESIDENT ANTHONY. Thank you very much. We apparently have elected Thomas R. Camp as the president of this Association.

At this time comes the end of my year's service to the Association as president.

Presidential Address by Sidney S. Anthony

We are at the end of another milestone in the history of this ancient and honorable Association, the year 1950 being the 68th of its life. In recent years the membership has increased gradually to a total of 930 at the latest count available to me.

The membership is divided geographically among 34 states, territories and foreign countries. Of these 34, Maine ranks fourth in number of active members, being led only by Massachusetts, Connecticut and New York in that order. It seems entirely possible to attain a goal of 1,000 during the next twelve months. We are certain to accept into membership more than the 70 required, but we are also sure to lose a few by death, resignation or other causes. Therefore we need to invite more than 70 individuals, to reach the goal.

The past year has not been distinguished by any particularly great accomplishment, except a gradual increase in the interest shown by members, as indicated by their attendance at conferences—that held in June being next to the largest in attendance of any ever held.

A large count of memberships is not a true criterion of the value of any organization. A small and vigorous roster of names can be of great value to any professional association. A long list, covering a majority of the individuals engaged in any profession in a locality, a large percentage of whom are active, at least to the extent of attending conferences and listening to and discussing technical papers, provides the greatest benefit to that profession. If many of the members are engaged in active committee work, they and the whole association are of greater value to their respective communities.

This brings up the question of average age of technical committees. If we look over the names of men appointed to the committees of this Association, we find that many of them have been assigned to these same committees for years and that there are few names of the younger set among them. Would it not be wise to put some of the youngsters to work? During the past ten years 396 new active members have been admitted to membership. The proportion of men under 40 in this group is not known to me, but certainly a substantial number of newcomers to the profession, or men newly promoted to positions of responsibility, have applied for and have been accepted to our rolls. How many of them have been assigned to committee work?

After all, a man profits from his membership in direct ratio to the amount of thought and effort he puts into the Association's activities. I suggest that the Executive Committee, in its deliberations next month, give some thought to putting some of these men to work wherever they may be qualified. If they are not now qualified, assignment to a committee will require some study on their part, with consequent benefit to themselves as well as to the Association.

During the past few months the world situation has changed rapidly. For several years we have been engaged in what has been called a cold war. In June this cold war began to warm up a bit in an area not considered by some of us to be important, but it has possibilities of spreading to a series of small fires or of suddenly developing into a world-wide conflagration. With these possibilities in view, the Government seems to be preparing for an all-out effort and we find ourselves suddenly faced with growing shortages of materials, equipment and personnel.

Within the past few days our economy has suddenly been placed under controls by the Federal Government. To what extent we shall be directly affected is not known right now, but we can be sure that we shall be affected to a greater or less extent before the start of another construction season. And for how long? No one knows that, either. If we are lucky, it will be over soon, but that is doubtful, if we judge by published reports of the extent to which the Government has gone to enlist men, industry and materials to support the ideals of the United Nations and implement its forces.

I fear that we are in for many years of restricted economy, beside which the controls of the years 1941 to 1945 will seem like a picnic. What forms these controls take we know not at present, and only time and the directives of the National Production Authority will tell us. We must be prepared to accept them and get along as best we can under these controls.

Mutual-aid systems must be reactivated, together with centralized information as to inventories, and we must all be prepared to help neighbor utilities in case of emergency.

During World War II, under Civil Defense, our mutual-aid plans worked more or less successfully. We must be sure that present and future plans also are effective and adequate for conditions which may be foreseen.

No retiring president during the last few years has relinquished his duties without paying tribute to the unusually able and efficient assistance rendered by our Secretary, Joseph Knox, and Mrs. Alice Melrose, office assistant, without whose accurate knowledge of all the Association's affairs no president could conduct his office—particularly in my case, situated as I am more than 150 miles from headquarters. I also pay this tribute from the bottom of my heart.

The coöperation of the Water & Sewage Works Manufacturers Association, headed by our old friend, Reg Hayes, is still another reason why this Association is so successful in its activities. We may poke fun at the "pedlers" at times, but they are an essential part of any modern water utility or association. I know I speak for the whole membership when I express my thanks for their entertainment at this Annual Convention and other conferences of the Association.

I now present to you your new President, Thomas R. Camp, senior partner in the consulting engineering firm of Camp, Dresser & McKee.

PRESIDENT CAMP. Members of the New England Water Works Association, ladies and gentlemen:

The first thing I shall do is to thank the members of the Association for the trust they have placed in me to govern the affairs of the Association for the coming year. I am sure it is not going to be difficult at all, with the help of Joe Knox and Mrs. Melrose. It is not a hard job. And we have an excellent Board of Directors to help, too.

I know many of you have been wondering about the loneliness of Sid Anthony, and I don't know whether you know that Mrs. Anthony could not be present tonight because of the doctor's orders. We have missed her greatly. She is always a great source of happiness to all of us, and I know that Sid has been particularly lonely during this convention because of her absence. Mrs. Anthony would have loved to be here, too.

The affairs of the New England Water Works Association are in very good shape. For the past five years, since the end of World War II, we have been on relatively thin ice because of rising costs, and year after year our Finance Committee has recommended a deficit budget, so that perhaps the next year might show us just

where we were heading. Some of the five years have turned out very satisfactorily and we have come out in the black by a few hundred dollars, but in some of the others we have been a little bit in the red. Now, we do have a very substantial "kitty" of some $27,000, which has been accumulated over the years, and in case of emergency we can dip into that, but, as you business-men know, to keep doing that for a long while is not good business. So we have given some thought to the possibility of facing up to an increase in dues, but we are not going to think of it in the immediate future. We know a way to avoid it. Our dues are $6 and that is pretty cheap for what you get, and they have been that for quite a long while. There is an easy way to keep them at $6, and that way is to get new members, and it won't take very many to do it. This last year we had a gain of some fifty new members, but unfortunately we lost one more than that, so that we have a net loss of one member. Now, I should like each one of you to bring in a new member. If each one of you brings in a new member, we shall run through in the future without an increase in dues. It will not be difficult to do it.

I should like to express my appreciation, too, for the good times the Manufacturers Association gives to us. I don't know what we should do without their arrangements.

Bill Brenchick, who is in charge of the arrangements this year, will tell you what to do the rest of the evening, and I shall now turn the meeting over to him.

[*Adjourned.*]

ANNUAL REPORT OF THE SECRETARY

Mr. President and Members of the New England Water Works Association: The Secretary herewith submits the following report of the changes of membership during the past fiscal year and the general condition of the Association.

The present membership is 921, constituted as follows: 12 Honorary Members, 756 Members, 1 Junior Member, 120 Associate Members and 33 Corporate Members.

MEMBERSHIP

				Total
September 1, 1949—Honorary Members, Total		13		
Withdrawals:				
Died	1	1		12
September 1, 1949—Members, Total		758		
Withdrawals:				
Resigned	19			
Died	16			
Dropped by the Executive Committee	13	48	710	
Elected:				
September 12, 1949	9			
October 28, 1949	7			
November 17, 1949	1			
December 15, 1949	2			
January 19, 1950	7			
February 16, 1950	7			
March 16, 1950	3			
April 20, 1950	1			
April 20, 1950—Junior Member	1			
May 19, 1950	3			
June 22, 1950	5		46	756
September 1, 1949—Associates, Total		119		
Withdrawals:				
Resigned	4			
Dropped by the Executive Committee	1	5	114	

Elected:				
October 28, 1949	1			
March 16, 1950	2			
April 20, 1950	1			
May 19, 1950	2		6	120
September 1, 1949—Corporates, Total		32		
Withdrawals:				
Resigned	1	1	31	
Elected:				
September 12, 1949	1			
June 22, 1950	1		2	33
September 1, 1950—Total Membership				921
September 1, 1949—Total Membership				922
Loss of 1				

ELECTIONS

Members

September 12, 1949—Roland F. Burke, Dexter O. Fisher, Richard M. Heffernan, George H. McDonnell, Walter M. Nagle, Marshall R. Sharpe, Eric Schaefer and David H. Turcott. (8)
Reinstated—James E. Fuller. (1)

October 28, 1949—James W. Barrowclough, John W. Costigan, Herbert F. Howe, Edward R. Lawson and Francis N. O'Hara. (5)
Reinstated—Edward J. Murphy and Roger W. Macdonald. (2)

November 17, 1949—Maurice Brunstein. (1)

December 15, 1949—Wendell F. Esty and Morton I. Goldman. (2)

January 19, 1950—Matthew C. Allan, Neil B. Faunce, Frederick J. Haydock, George T. Stewart, William D. Twombly and Frederick B. Wood. (6)
Reinstated—Charles R. Moore. (1)

February 16, 1950—Francis X. Crowley, William Doubleday, William E. Duffy, Lester Gaynor, Frank J. O'Halloran, John A. Steinberg and Hyman J. Steinhurst. (7)

March 16, 1950—Lindsay M. Collins and Rolf Eliassen. (2)
Reinstated—Arthur C. Libby. (1)

April 20, 1950—Ladislaus T. Jodiatis. (1)
Junior Member—Llewellyn L. Cross, Jr. (1)

May 19, 1950—Alfred E. Kaeppel, Roy E. Kimball and Francis J. Turnbull. (3)

June 22, 1950—Charles M. Barry, Louis R. Cobb, Dorothy E. Dimmers, Alice R. Melrose and Eugene J. O'Neil, Jr. (5)

Associate Members

October 28, 1949—Pioneer Foundry and Manufacturing Company, Inc. (1)

March 16, 1950—S. Morgan Smith Company. (1)
Reinstated—Bowser, Incorporated. (1)

April 20, 1950—Reinstated—Revere Copper and Brass Company. (1)

May 19, 1950—Walker Process Equipment, Incorporated, and Walsh Holyoke Boiler Works Division. (2)

Corporate Members

September 12, 1950—North Reading Board of Public Works. (1)
June 22, 1950—Buzzards Bay Water District. (1)

WITHDRAWALS

Members

Resigned: Frederick B. Atherton, Harold W. Blake, Richard R. Bradbury, Nicholas Ciaburri, J. Edward Cox, George D. Dame, Morton I. Goldman, Guy E. Griffin, Robert A. Harrington, Aram H. Hatch, R. W. Hendricks, Samuel J. Kyle, Carter H. Lamb, John M. Littlefield, Willard S. MacFadyen, Robert W. Muther, Jr., W. Frederick Spence, Theodore E. Stimpson and Harold M. Tarr. (19)

Died: William T. Barnes, William James Eames Binnie, Sidney K. Clapp, Arthur T. Clark, Harry W. Clark, Edward S. Cole, John H. Cook, George H. Finneran, Charles T. Gilliard, H. Herman Hitchcock, Clarence W. Hubbell, Morton L. Miller, Edward Nuebling, Clyde Potts, Albert W. Read, James F. Sanborn and George F. West. (17)

Dropped by the Executive Committee: Ivan A. Buchanan, George V. Clapp, Harry W. Dotten, Terrance J. Durant, John A. Hastings, James E. Kenney, John W. McCarthy, John H. Miller, Paul M. Nickerson, Chester L. Nyman, Clayton E. Osborn, Charles A. Root and Wilbur D. Smith. (13)

Associate Members

Resigned: American Brass Company, Cla-Val Company, Monsanto Chemical Company and Tate Pipe Linings, Inc. (4)

Dropped by the Executive Committee: Cia Exploradora y Perforadora Agua y Minerales. (1)

Corporate Members

Resigned: Warwick Water Department. (1)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1949, TO SEPTEMBER 1, 1950

Entrance Fees	$ 158.00
Dues of Members of all grades	7,550.50
Dividends	578.57
Advertisements	5,814.75
Subscriptions	664.40
Journals	56.09
Membership Certificates	24.00
Total Receipts	$14,846.31
There is due the Association:	
Dues	90.00
Advertising	75.00
Total	$15,011.31

Respectfully submitted,

(*Signed*) JOSEPH C. KNOX, *Secretary*

ANNUAL REPORT OF THE TREASURER

Boston, September 11, 1950

To William P. Melley, Treasurer,
New England Water Works Association,
Boston, Massachusetts.

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the year ended August 31, 1950. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

We traced all recorded receipts into the depositary bank, verified the general fund bank account and petty cash fund as at August 31, 1950, and examined properly approved vouchers for all disbursements. We also verified by direct communication the investment funds on deposit in savings and coöperative banks, and on September 6, 1950, we examined the United States Treasury savings bonds at the First National Bank of Boston.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related statement of cash receipts and disbursements of the general fund present fairly the financial position of the New England Water Works Association at August 31, 1950, and the recorded cash receipts and disbursements for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) SCOVELL, WELLINGTON & COMPANY

STATEMENT OF ASSETS AND FUNDS (Exhibit A)

As at August 31, 1950

Assets		
Cash in banks, invested funds		
Farmers and Mechanics Savings Bank, Framingham, Massachusetts	$ 1,000.00	
Franklin Savings Bank, Boston, Massachusetts	1,000.00	
Haverhill Savings Bank, Haverhill, Massachusetts	1,000.00	
Home Savings Bank, Boston, Massachusetts	1,000.00	
Mechanics Savings Bank, Reading, Massachusetts	1,000.00	
Pentucket Savings Bank, Haverhill, Massachusetts	1,000.00	
The People's Savings Bank, Worcester Massachusetts	1,000.00	
Suffolk Savings Bank, Boston, Massachusetts	1,000.00	$ 8,000.00
Securities		
U. S. Treasury savings bonds G 2½s, 1954	$10,000.00	
25 shares Milton Co-operative Bank, series of June, 1940	3,683.00	13,683.00
Total invested cash and securities		$21,683.00
General fund		
Cash, First National Bank of Boston	$4,914.63	
In office	50.00	
	$4,964.63	
Furniture and fixtures	1,180.00	6,144.63
		$27,827.63
Funds		
Invested funds		$21,683.00
General fund		
Balance, August 31, 1949	$6,077.67	
Less Purchase of Milton Co-operative Bank shares	300.00	
	$5,777.67	
Excess of receipts over disbursements, Exhibit B	366.96	

Balance, August 31, 1950	6,144.63
	$27,827.63

Note: The statement above, prepared on a cash basis, includes dues received in advance, $4,036, and employees' withholding tax, $85.90. It does not reflect the following:

Accounts receivable, dues	$ 90.00
Due on account of advertising	75.00
	$ 165.00

No depreciation has been taken on furniture and fixtures.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS (Exhibit B)

General Fund

For the Year ended August 31, 1950

Receipts (exclusive of dues received in advance and employees' withholding tax)			
Initiation fees		$ 158.00	
Dues, 1949-1950 and prior years		3,514.50	
Interest		578.57	
From publication of Journal			
Advertisements	$5,814.75		
Subscriptions	664.40		
Sale of Journal	56.09	6,535.24	
Miscellaneous			
Membership certificates		24.00	
Total receipts			$10,810.31
Disbursements			
Publication of Journal			
Printing	$3,049.07		
Plates	662.69		
Reprints	315.56		
Reporting	315.68		
Stationery and postage	113.78		
Editor's salary	750.00		
Sundry	33.73	$ 5,240.51	

General and administrative			
Certificates of membership	$ 12.75		
Secretary's salary	750.00		
Assistant to secretary—salary	2,539.00		
Treasurer's salary	200.00		
Printing, postage and stationery	247.23		
Office supplies and expense	284.96		
Office rent	1,020.00		
Electricity	93.05		
Telephone and telegraph	305.29		
Auditing	85.00		
Social security taxes	82.45		
Printing membership list	541.18		
Fidelity bonds	93.75		
Sundry	82.05	6,336.71	
Meetings and committees			
Water works school	$ 125.00		
Printing, postage and stationery	1,034.60		
Convention expense	446.66		
Dinners	758.59		
Contribution to June conference	150.00		
Sundry expense	283.89	2,798.74	
Interest added to co-operative bank shares		102.50	
Total disbursements			$14,478.46
Excess of disbursements over receipts (exclusive of dues received in advance and employees' withholding tax for current year)			$ 3,668.15
Dues received in advance		$4,036.00	
Employees' withholding tax			
Payment for prior year	$ 86.79		
Less Receipts for current year	85.90	.89	4,035.11
Excess of receipts over disbursements, Exhibit A			$ 366.96
Balance, general cash, August 31, 1949		$4,897.67	
Less Purchase of Milton Co-operative Bank shares		300.00	4,597.67
Balance, general cash, August 31, 1950			
Represented by			
Cash in First National Bank of Boston		$4,914.63	
Cash in office		50.00	
			$ 4,964.63

ANNUAL REPORT OF THE EDITOR

To the New England Water Works Association:

The Editor submits herewith his report for the year ending August 31, 1950.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received and disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1949, and March and June, 1950, issues of the JOURNAL is included in the report of the Treasurer.

In Table 1 is presented a statement of the material contained in the four issues of the JOURNAL for the past year, while in Table 2 is given a comparison of the JOURNAL for the past year with those for preceding years.

TABLE 1.—STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1949, AND MARCH AND JUNE, 1950, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION

	Papers	Proceedings*	Total text	Index	Advertisements	Cover and contents	Insert plates	Total pages	Total cuts
Sept., 1949	102	4	106	0	47	4	4	161	29
Dec., 1949	44	81	125	7	47	4	2	185	19
Mar., 1950	76	30	106	0	49	4	7	166	28
June, 1950	94	9	103	0	47	4	0	154	6
Total	316	124	440	7	190	16	13	666	82

*Including standard specifications.

Size. The four issues contained 666 pages, of which 440 were text.

Cost. The gross cost of the JOURNAL was $5,240.51, equivalent to $5.69 per member; the surplus was $1,294.73, equivalent to $1.41 per member.

Reprints. Reprints of papers have been furnished to authors at cost.

TABLE 2.—COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION
Four Issues for Fiscal Year Ending August 31

	1941[1]	1942[2]	1943[3]	1944	1945	1946	1947	1948[4]	1949[5]	1950[6]
Average edition (copies printed)	1,100	1,100	1,175	1,200	1,200	1,200	1,275	1,350	1,325	1,250
Average membership	800	803	798	799	806	820	846	876	905	921
Circulation at end of year	943	982	969	1,015	1,032	1,042	1,083	1,129	1,164	1,172
Pages of text	540	575	442	442	438	391	428	411	452	440
Pages of text per 1,000 members	675	716	554	553	543	477	516	469	500	477
Total pages, all kinds	733	757	616	621	630	586	632	615	661	666
Total pages per 1,000 members	918	943	772	777	782	715	747	702	731	723
GROSS COST:										
Total	$4,415.00	$4,053.47	$4,234.68	$3,406.48	$3,734.19	$4,053.08	$4,193.60	$4,239.64	$5,016.44	$5,240.51
Per copy	1.00	0.93	0.90	0.71	0.78	0.84	0.82	0.78	0.95	1.05
Per page	5.66	5.36	6.87	5.49	5.83	6.91	6.63	6.90	7.60	7.86
Per member	5.52	5.05	5.31	4.26	4.63	4.94	4.96	4.84	5.55	5.69
Per member per 1,000 pages	7.53	6.67	8.61	6.87	7.35	8.43	7.85	7.87	8.40	8.55
Per member per 1,000 pages of text	10.21	8.78	12.01	9.66	10.57	12.62	11.58	11.78	12.28	12.92
SURPLUS:										
Total	$276.54†	$534.72†	$609.81†	$407.21	$455.57	$162.33	$913.91	$1,990.81	$1,058.96	$1,294.73
Per copy	0.06†	0.12†	0.13†	0.08	0.09	0.03	0.18	0.37	0.20	0.26
Per page	0.38†	0.71†	0.99†	0.66	0.72	0.28	1.44	3.32	1.60	1.94
Per member	0.35†	0.67†	0.76†	0.51	0.57	0.20	1.08	2.28	1.17	1.41
Per member per 1,000 pages	0.47†	0.88†	1.24†	0.82	0.90	0.34	1.71	3.71	1.77	2.12
Per member per 1,000 pages of text	0.64†	1.16†	1.73†	0.92	1.29	0.51	2.52	5.55	2.59	3.20

[1]Including comprehensive index, 1882 to 1939, and 102 pages of standard specifications.
[2]Including 45 pages of standard specifications.
[3]Including 28 pages of standard specifications.
[4]Including 54 pages of standard specifications.
[5]Including 107 pages of standard specifications and recommended practice.
[6]Including 25 pages of standard specifications.
†Net cost.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	921
Subscribers	162
Exchanges	24
Advertisers	65
Total	1,172

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,

(*Signed*) GEORGE C. HOUSER,
Editor

ANNUAL REPORT OF THE FINANCE COMMITTEE

August 31, 1950

To the Executive Committee of the New England Water Works Association

Gentlemen:

Your Finance Committee herewith presents its report on the budget for the fiscal year 1949-50 and its recommended budget for 1950-51.

The following tabulation shows the estimated and actual budget figures for 1949-50:

REVENUE FOR 1949-50

	Budget	Actual	Difference
Initiation fees	$ 175.00	$ 158.00	—$ 17.00
Dues	6,800.00	7,550.50	+ 750.50
Interest and dividends	500.00	476.07	— 23.93
Journal	6,000.00	6,535.24	+ 535.24
Miscellaneous	50.00	— 62.79*	— 112.79
	$13,525.00	$14,657.02	+$1,132.02

DISBURSEMENTS FOR 1949-50

	Budget	Actual	Difference
General and administrative	$ 6,000.00	$ 5,709.63	—$ 290.37
Journal	5,000.00	5,240.51	+ 240.51
Meetings and committees	3,200.00	2,798.74	— 401.26
Contingencies	500.00	.....	— 500.00
Membership list	500.00	541.18	+ 41.18
	$15,200.00	$14,290.06	—$ 909.94

The estimated deficit was $1,675, but we came out with an actual surplus of $366.96, and the total funds on hand total $27,827.63.

Considering first the revenue items, there was a substantial increase in dues, but this was because more dues were paid in advance

*Collected from employees for social security and withholding tax, but not paid.

than in former years, the total membership not having increased over last year. There was also an increase in the "Journal" item, due to larger advertising revenue.

Reviewing now the disbursements, the item "general and administrative" is less, due to a decrease in office expenses. The increase in the item "Journal" was due to a larger expenditure for plates and reprints. The item "meetings and committees" was less, due mainly to a smaller expenditure for the Annual Convention. The printing of the membership list cost slightly more than estimated.

In setting up our budget for 1950-51, we believe that the policy, inaugurated in 1946, of having an unbalanced budget should be continued, inasmuch as future economic conditions appear now more uncertain than ever.

It might be pointed out here that the reason for doing this is that, should the estimated deficit actually occur, it will not be necessary for the Committee to appear before the whole Association and request additional funds.

BUDGET FOR 1950-51

Revenue	
Initiation fees	$ 150.00
Dues	7,000.00
Interest and dividends	500.00
Journal	6,200.00
Miscellaneous	50.00
	$13,900.00
Disbursements	
General and administrative	$ 6,400.00
Journal	5,300.00
Meetings and committees	3,200.00
Contingencies	500.00
Index for the Journal	800.00
	$16,200.00
Deficit	$ 2,300.00

The dues have been estimated by using an average of the last three years and the other revenue items are, we believe, on the conservative side. As previously mentioned, our membership has apparently reached a static point and, to ensure our revenue in the future,

your committee recommends that some effort be made to increase the membership. A cursory study of municipalities of over 10,000 in New England shows that only 60% of the water-works superintendents are members.

If there is not a substantial increase in membership during the next year, it may be necessary to increase the dues from $6.00 to $8.00.

The disbursement items have been set up with an eye to probable increases in costs in the coming year. A new index for the JOURNAL is long overdue, the last one being issued in 1939. This will greatly enhance the usefulness of the JOURNAL. The Executive Committee voted last year to do this, and also that in the future the membership list be issued every five years and a new index every ten years.

In considering the possibility of our actual deficit of $2,300 occurring, your committee recommends that, if the cash in the general fund or operating account drops below $2,000, the Treasurer be authorized to transfer funds from the savings accounts up to $1,000 to the general fund.

We refer you to the Treasurer's report for further financial details and to the Secretary's report for the changes in the membership roster.

Respectfully submitted,

(*Signed*) KENNETH W. ROBIE, *Chairman*
SYDNEY C. BEANE
HENRY F. HUGHES

ANNUAL REPORT OF THE COMMITTEE ON LEGISLATION

September 18, 1950

To the New England Water Works Association:

Your Committee on Legislation herewith presents its report on activity in the legislatures of the New England states during 1950.

No sessions, either regular or special, were held in the States of Maine and Vermont this year. Connecticut and New Hampshire called special sessions to consider several matters of immediate importance. However, none of these had any bearing on the water-works field.

Regular sessions were held in Massachusetts and Rhode Island, the latter calling a special session in addition.

In Massachusetts, the Special Commission, authorized under Chapter 70 of the Resolves of 1949 to make a further investigation relative to "the development and use by cities and towns of Water Supply Systems and Sources of Water Supply", submitted its final report under date of March 20, 1950. At a subsequent hearing before the Legislative Committee on Water Supply, the proposed legislation was strenuously opposed by local budgeting officials, resulting in a decision by the Committee to recommend reference of the subject to the next annual session, said recommendation being duly accepted by the Senate and House.

There was enacted into law Chapter 41 of the Resolves of 1950, which authorizes the Department of Public Health to make an investigation and study relative to the ground-water supply and its use and protection within the Commonwealth, said Department to present its report on the subject to the Legislature on the first Wednesday in December of the current year.

House Bill #2458, entitled "An Act to authorize the levy of special assessments for the laying of water pipes in public ways", was passed by both branches of the Legislature and sent to the Governor for his signature. It was then recalled by the Senate and rejected.

During the 1950 session a number of Special Acts, either creating water districts or providing for an increase in the borrowing limits of certain municipalities and water districts, were enacted into law.

The General Assembly of the State of Rhode Island passed into law two Acts relating to the water systems of the towns of North and East Providence. However, proposed legislation, entitled "An Act in Amendment of and in Addition to Chapter 29 of the General Laws, entitled 'Property Liable to, and Exempt from, Taxation'," after introduction at the request of the Water Supply Board of the city of Providence, failed of passage.

Respectfully submitted,

(*Signed*) MARK F. CROKER, *Chairman*
THEODORE L. BRISTOL
WALTER C. CONROY
G. ARTHUR FANEUF
PHILIP J. HOLTON, JR.
EDWIN T. McDOWELL
EDWARD L. TRACY

ANNUAL REPORT OF COMMITTEE ON COMMITTEES—1950

To the New England Water Works Association:

This committee, appointed by the Executive Committee of the Association to promote coördination of committee activities in the Association and to promote the establishment of new technical committees where this seems advisable, submits its report. Our committee has followed its usual practice of communicating with the various committee chairmen to ascertain their ideas as to continuance of committees and their plans with regard to reports. We have also been in touch during the year with other associations regarding joint committees. The Technical Program Committee has been advised as to those committees desiring to submit reports at the annual meeting.

Inactive committees should be dispensed with. There are some joint committees with other associations, however, dealing with preparation and approval of certain standards, where progress may be unavoidably slow in getting out reports. In writing to committee chairmen this year, this committee again stressed the desire of the Executive Committee to weed out inactive committees.

Listed below are committees which, in the opinion of this committee, should be continued, together with some notations as to activities where information is available through the committee chairmen. In the case of most of the following committees, the committee chairmen have expressed the opinion that the committees should be continued:

*Committee on Technical Program.
*Committee on Finance.
*Committee on Membership.
*Committee on Library.
*Committee on Committees.
*Committee on Legislation.
*Committee on Reciprocal Relations with the Institution of Water Engineers.

*Expects to submit report at 1950 annual meeting.

Committee on Classification of Water Works Employees and Salaries. This committee hopes to have a report at the close of the year.

Committee on Survey of Ground Water Supplies in New England.

**Committee on Rainfall and Yield of Drainage Areas. This committee expects to discuss 1949 drought conditions.

Committee on Cathodic Protection of Steel Tanks and Standpipes.

Committee on Coëfficients for Friction in Pipe Lines.

**Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation.

**Committee on Reinforced Concrete Pressure Pipe. (Joint Committee with A.W.W.A.)

Committee on Code for Pressure Piping. (Joint Committee with A.S.M.E.)

*Committee on Laying Cast-Iron Pipe (Joint Committee with A.W.W.A.) This committee may submit final report.

**Committee on Specifications for Steel Pipe. (Joint Committee with A.W.W.A.)

*Committee on Steel Standpipes and Elevated Tanks. (Joint Committee with A.W.W.A.)

Committee on Valve Box Frames and Covers. (Joint Committee with A.W.W.A.)

**Committee on Hydrant Specifications. (Joint Committee with A.W.W.A.)

**Committee on Gate Valves. (Joint Committee with A.W.W.A.)

Committee on Federal Activities. (Joint Committee with A.W.W.A.)

**Committee on Fluid Permeability. (Sectional Committee under A.S.A.)

**Committee on Deep-Well Vertical Pumps. (Sectional Committee under A.S.A.)

Committees Not Reporting

The following committees are joint committees assigned to important subjects and they are presumably working toward the submission of reports, but no information has been received from the

**Expects to submit progress report at 1950 annual meeting.

committee chairmen as to the status of the work or the continuance of the committees during at least the past two years. The Executive Committee may wish to check further on the status of the work of these committees.

Committee on Specifications for Cast-Iron Pipe and Fittings. (Sectional Committee under A.S.A.)

Committee on Standardization of Pipe Flanges and Fittings. (Sectional Committee under A.S.A.)

Committee on Sluice Gates. (Coöperating with A.W.W.A.)

Discontinuance of Committees

Committee on Water Quality Tolerances for Industrial Uses. This committee may submit a final report this year, in which case the chairman suggests that the committee be discontinued.

Committee on Meter Specifications. (Joint Committee with A.W.W.A.)

The committee chairman reports that if favorable action is taken on recommended specifications by the N.E.W.W.A. at the September meeting, the committee should be discontinued.

During the past year, the following committees were discontinued:

Committee on Distribution System Safety.

Committee to Investigate Grounding. (Coöperating with the American Research Committee on Grounding)

New Committees

During the year, joint committees were appointed on Fluid Permeability and on Deep-Well Vertical Pumps. In view of the rapidly changing world situation, it is probable that new problems may arise to face water-works officials. These will undoubtedly include defense aspects and may include important questions as to deferment of key personnel and priorities for materials needed to maintain the public health and assist in defense measures.

It is recommended that the Executive Committee give consideration to the appointment of two committees, one of which might be designated a committee on defense measures. To this committee, as

a start, there might be appointed the chief engineer of the state department of health of each New England state or other members of the Association who might be serving as state water coördinators.

The appointment of a second committee might be considered, which might be primarily concerned with problems relating to deferments and priorities. There is some question in the minds of this committee as to the objectives of the Committee on Federal Activities, which is a joint committee with the A.W.W.A. Possibly if a committee on deferments and priorities were established, the Committee on Federal Activities might be incorporated in the new committee, unless there is some other definite reason for the existence of the Committee on Federal Activities of which this committee is not aware.

Our committee has apparently accomplished little in connection with its past recommendations for the establishment of a program of public education in the water-supply field, through paid expert service or in some other way. We still are of the opinion that this objective should be sought.

Conclusions and Recommendations

It is recommended that the standing committees listed above be reappointed as indicated, that the activities of a few committees, listed separately, which have not reported, be further checked, that two committees listed be discontinued, if the committee reports so recommend, and that consideration be given to establishment of two committees in connection with the defense program.

Respectfully submitted,

(*Signed*) WARREN J. SCOTT, *Chairman*
HORACE L. CLARK
ROGER W. ESTY
EARL R. PERRY
WILLIAM E. STANLEY

REPORT OF TECHNICAL PROGRAM COMMITTEE

To the New England Water Works Association:

The report of the Chairman of the Technical Program Committee contains little that is different from similar reports in other years. Technical programs have been provided for five meetings in Boston, the Spring Conference and the Annual Meeting. In addition, Spring meetings were held at Newport, R. I., and Pittsfield, Mass.

At the Boston meetings, in addition to the formal papers presented after the luncheons, the Superintendents' and Chemists' Round Tables have been held, the former in charge of George G. Bogren of Weston and Sampson, and the latter in charge of Sherman L. Rogers of the Metropolitan District Water Bureau, Hartford.

Mr. Bogren, who has so ably taken charge of the Chemists' session, has asked to be relieved of this assignment. The Chemists' Round Table has had a series of excellent discussions by well qualified speakers and discussion leaders, and for this Mr. Bogren has been largely responsible. The Committee wishes to express regret at his relinquishing this duty and thanks him for his efforts.

As you can see by the list of meetings, some twenty-five formal papers have been given. Needless to say, the securing of this large number of papers, a much heavier load than in most engineering societies, imposes a heavy burden on your Technical Program Committee. If we are to continue to obtain papers of high quality, we must have the coöperation of all members, both in writing papers and in passing on information as to subjects and ideas to the Committee. We are constantly asked to have more papers by superintendents, and of a more practical nature. The Committee would be pleased—in fact, very much pleased—to schedule such papers but must have the material prepared. I regret to say that many who are making this criticism are not those who offer discussions for the luncheon meetings, though many do talk before the superintendents' meetings.

The Chairman wishes to take this opportunity to thank the mem-

bers of the Committee and the President, Secretary and Assistant Secretary of the Association, without whose help and coöperation our fine series of technical meetings would not have been possible.

Respectfully submitted,

(*Signed*) TRUMAN H. SAFFORD,
Chairman

REPORT OF THE COMMITTEE ON MEMBERSHIP—1950

August 31, 1950

To the New England Water Works Association:

The Membership Committee submits herewith the following report of changes of membership in the Association during the past fiscal year.

New Members

	Regular	Junior	Associate	Corporate	Total
	45	1	6	2	54

Loss of Members

Resigned	19		4	1	24
Died	17				17
Dropped	13		1		14
	49		5	1	55

Total membership as of August 31, 1950—921.

Total membership as of September 18, 1950—932.

Respectfully submitted,

(*Signed*) JOHN B. KENNEDY, *Chairman*
THEODORE CATE
HAROLD W. GRISWOLD
J. ELLIOTT HALE
JOSEPH E. MOORE
WALTER J. SHEA

REPORT OF COMMITTEE ON RECIPROCAL RELATIONS WITH THE INSTITUTION OF WATER ENGINEERS

September 18, 1950

To the New England Water Works Association:

The Committee on Reciprocal Relations with the Institution of Water Engineers of Great Britain presents herewith its report for the past year:

The Committee wishes to call attention to the loss by death of two members of the Institution of particular interest to the Association: first, that of W. J. E. Binnie, an honorary member of the NEWWA and a distinguished water-works engineer, whose memoir occurs in the January, 1950, issue of the JOURNAL; second, that of A. T. Hobbs, Secretary of the Institution, whose interest in the reciprocal relations arrangement was an important factor in its success. Mr. Hobbs was a man of quiet efficiency and courteous manner. His services to the Institution of Water Engineers were invaluable. He has been succeeded by W. O. Skeat, with whom your Committee has already had cordial correspondence.

As you know, the reciprocal arrangement calls for the exchange of outstanding papers on water-works subjects at intervals of four years, alternating at two-yearly intervals. It is now time for the Institution to select an Association paper for republication in the Journal of the Institution. Your Committee has sent to Mr. Skeat four of the outstanding papers of the Association published during the years 1946-1949, inclusive. It will be a few months before your Committee will be informed of the selection made by the Institution.

Another matter of interest is the recent publication by the Institution of the "Manual of British Water Supply Practice," for the editing of which Mr. Hobbs was largely responsible. Those wishing to obtain copies of this manual should communicate with the office of the Association or with this Committee.

Respectfully submitted,

(*Signed*) E. SHERMAN CHASE, *Chairman*
LELAND G. CARLTON
PERCY A. SHAW

REPORT OF COMMITTEE ON REINFORCED CONCRETE PRESSURE PIPE

To the New England Water Works Association:

Revisions of Committee 7A of the AWWA to tentative specifications for Reinforced Concrete Pipe—Steel Cylinder Type, non-prestressed, and for Reinforced Concrete Pipe—Steel Cylinder Type, prestressed, are being considered for recommendation to the Water Works Practice Committee for adoption and to make the specifications standard.

Your committee was represented at the meeting of Committee in Philadelphia in May, where considerable discussion developed over the revisions.

The Committee also decided to prepare, with the approval of the Water Works Practice Committee, tentative standard specifications for Reinforced Concrete Pipe, non-prestressed, without a steel cylinder, for use in water works where the static head would be 100 feet or less.

Although considered, it finally decided to delay action upon preparation of specifications for Reinforced Concrete Pipe, prestressed, without a steel cylinder, as it was believed that the progress in the art and manufacture has not reached a stage warranting the preparation of standard specifications.

Respectfully submitted,

(*Signed*) STANLEY M. DORE
GEORGE A. SAMPSON

PROGRESS REPORT OF COMMITTEE ON LAYING CAST-IRON WATER MAINS

September 11, 1950

To the Members of the New England Water Works Association:

Your Committee on Laying Cast-Iron Water Mains was appointed to coöperate with the American Water Works Association in revision of the 1938 AWWA Standard Specifications for Laying Cast-Iron Pipe. A document reported by the Joint Committee and entitled "A Procedure for Disinfecting Water Mains" was published in the February, 1948, Journal of the AWWA. Some major revisions in the procedure are currently under consideration.

The laying of mains, as distinguished from their disinfection, was covered by the Committee in "Tentative Specifications for Installation of Cast Iron Water Mains", published in the December, 1949, issue of the AWWA Journal. This document will doubtless be considered for adoption as "Standard" by the AWWA early in 1951.

Both the "Procedure" and the "Specifications" contain recommendations which have been the subject of further research and discussion since they were originally published. In view of this, and the possibility of change before the documents are adopted as "Standard," your Committee feels that it should not submit a final report at this time, as it had hoped to do.

Respectfully submitted,

(*Signed*) W. S. MARINER, *Chairman*
GEORGE W. COFFIN

REPORT OF COMMITTEE ON SPECIFICATIONS FOR STEEL PIPE

To the New England Water Works Association:

Revisions of the tentative standard specifications of the AWWA 7-B for steel pipe, 30-inch, are in progress, pending final adoption by the Water Works Practice Committee of that society.

One of your committee attended a meeting of the Committee in Philadelphia at the annual convention of the AWWA in May and several revisions were discussed at length.

Suggested revisions were also received by mail for ballot.

The tentative specifications have been printed in the society JOURNAL and the revisions suggested will be brought before this society, if adopted, for consideration.

If the tentative specifications are adopted as standard, this committee recommends that our society consider them for further approval.

Respectfully submitted,

(*Signed*) STANLEY M. DORE
SCOTT KEITH

REPORT OF HYDRANT SPECIFICATION COMMITTEE

To the Members of the New England Water Works Association:

Your Hydrant Specification Committee is not ready to make a final report.

The American Water Works Association's Committee on Hydrant Specifications has made a final report on the revision of Hydrant Specifications, and as soon as that Association accepts them, then this Committee will be ready to make a final report.

Respectfully submitted,

(*Signed*) ROGER W. ESTY, *Chairman*
HAROLD W. GRISWOLD
HARRY U. FULLER

REPORT OF COMMITTEE ON GATE VALVE SPECIFICATIONS

September 16, 1950

To the New England Water Works Association:

Your Committee on Gate Valve Specifications submits the following progress report for the year ending September, 1950.

Early in the year a suggestion, originating with Mr. Harry Barton of Great Neck, L. I., that the specifications require valve stem collars to be made with taper seats, to facilitate repacking under pressure, was disapproved unanimously.

A revised draft of the valve specifications was received from Secretary Harry Jordan of the A.W.W.A., dated March 1st. Comments on this draft were made by each member of the committee and copies sent to both Chairman Randlett and Secretary Jordan.

At the Philadelphia Convention of the A.W.W.A. a meeting of the joint committee was held, at which none of the New England members were able to be present. Secretary Jordan reported on this meeting under date of July 26th as follows:

"We had a meeting with the representatives of the manufacturers during the Philadelphia Convention, at which time the manufacturers' group presented a wide variety of suggestions both as to detailed terminology, as well as to general arrangements of the Valve Specifications.

"I asked the Chairman of the Committee, Mr. Carl Simons of the Darling Valve Company, to set the document up in parallel column fashion. That is being done. Copies of the material will go to the members of the Committee as soon as Mr. Simons sends it into this office."

It is recommended that the New England Committee on Gate Valve Specifications be continued until such time as the current revision of these specifications is completed.

Respectfully submitted,

(*Signed*) HAROLD W. GRISWOLD, *Chairman*
LELAND G. CARLTON
WALTON H. SEARS

REPORT OF FLUID PERMEABILITY COMMITTEE

To the New England Water Works Association:

Although the work of this committee has not been particularly active, nor has the national organization with which your representative coöperates made any rapid progress in study or research in connection with the permeable qualities of soils or overburdens, your representative has answered questionnaires and has been in touch by correspondence with the national group.

The main progress to date has been an expression of opinion in a national poll of the proper use of terms and definitions, and a discussion of the fundamental factors to be considered in any future discussions. An effort has been made to establish standard terms and factors, to avoid misunderstandings in correlating data and opinions from representatives in various parts of the country.

Respectfully submitted,

(*Signed*) STANLEY M. DORE

REPORT OF COMMITTEE ON SPECIFICATIONS FOR CAST-IRON PIPE AND FITTINGS

August 16, 1950

To the New England Water Works Association:

Your representatives on Committee A21 of the American Standards Association on Specifications for Cast-Iron Pipe and Fittings submit the following annual report.

Progress during the year has included a revision of the specifications for pit-cast pipe, with particular reference to bursting tests, which have been modified to reconcile them to those that have been adopted for centrifugal pipe. Changes in the specifications for cement lining are in progress in conformity with changes in the state of the art. A change of particular interest is that permitting the application of a bituminous seal coat on the freshly spun lining, to shorten the period previously required for curing.

Specifications for mechanical joints have been tentatively completed and are about to be submitted for letter ballot of the Sectional Committee. The manual for the "Computation of Strength and Thickness of Cast Iron Pipe", A21.1-1939, has been revised and in its new form will consist of three parts: the first, to include historical information and explanation of the method of computation of external loads, etc.; the second, to deal with cast-iron pipe for water; and the third, to cover cast-iron pipe for gas. This change has been considered necessary because of differences in the requirements of the water and gas industries in respect to water hammer and other design details.

The matter of specifications for tar-dip coatings has again been discussed, but there appears to be but little hope of reconciliation between manufacturers' existing methods and the ideals of the waterworks industry.

Respectfully submitted,

(*Signed*) ELSON T. KILLAM
ARTHUR L. SHAW

REPORT OF THE COMMITTEE ON RAINFALL AND YIELD OF DRAINAGE AREAS RELATIVE TO THE DROUGHT OF 1949-1950

To the New England Water Works Association:

The drought of 1949-50 began with the first of June, 1949, and has continued generally with little relief to the time of writing this report. This drought has been more severe in the southerly portions of New England than any previous drought since that beginning in June, 1908, except in certain portions. The effects of this drought have been more pronounced because of the delay since the beginning of World War II in constructing adequate works to keep pace with increased use of water, because of shortage of materials during the war period and the demands for the use of public funds for other purposes since the end of the hostilities of World War II. Through the courtesy of the various State Sanitary Engineers, water shortages have been reported to have continued in 1950 in the several New England States as follows:

NUMBER OF AGENCIES SUFFERING WATER SHORTAGES

State	Shortages in sources of supply	Shortages because of distribution difficulties
Maine	1 near the coast	3 near the coast 1 in the far north
New Hampshire	1 near the coast 1 in the Connecticut River Valley 1 East Central Section	
Vermont	8 generally distributed in 1949 (all but one corrected before 1950)	1 East Central in 1949 (corrected before 1950)
Massachusetts	4 Northeastern 1 Merrimack River Valley 1 Eastern Section 2 Southeastern Section 2 Central Section 1 Western Section	2 Metropolitan Area
Rhode Island	6 near Narragansett Bay	

Connecticut	3 near the coast
	2 North Connecticut River Valley
	2 Central Connecticut River Valley
	2 Western Section

The laws of the several New England States vary somewhat, but certain of the special legislative acts permit municipalities and water districts to establish rules and regulations for the operation of the works and such regulations include the right of the municipality or other agency to restrain the use of water during periods of drought. In at least one of the New England States an amendment has been made in order to make certain that all public water-supply agencies have that authority. This General Act reads as follows:

> "A board of water commissioners or a board of public works with the duties of water commissioners of a municipality, water supply, fire and water district or water company having control of water supplies may, on behalf of their respective bodies politic or corporate, upon notification to the water takers, restrain the use of water on public and private premises by shutting off the water at the meter or at the curb cock or by other means as the case may be, during a drought, hurricane, conflagration or other disaster when in the opinion of the department of public health an emergency exists."

In the interests of good public relations few municipalities have taken advantage of this law, except that when requesting voluntary restrictions in the use of water, attention has been called to the possibility of invoking the authority of the law actually to shut off water, if voluntary compliance is not experienced.

There are appended to this report tabulations showing the precipitation departure from normal since June 1, 1949, subdivided by States and within States by districts so far as practicable. This information is shown on Appendix I. It will be noted that the greatest deficiencies in rainfall have occurred in Rhode Island, Central Massachusetts and Eastern Massachusetts. Rainfall for the period in northern Maine and northern New Hampshire was near normal and tabulations for these areas are not shown.

Through the courtesy of the U. S. Geological Survey, there are shown in Appendix II tabulations of stream flow at various key stations in New England and the accumulated deficiency in runoff due to the lack of normal rainfall.

The Committee is informed that in Massachusetts the Legislature has directed the Department of Public Health to carry out a study, under the provisions of Chapter 41 of the Acts of 1950, relative to the ground-water supply and its use and protection within the Commonwealth. This study has progressed to the point where it is evident that the laws in various States of the country vary considerably from the old so-called Common Law or English Law. The tendency has been to recognize that the natural resources, including water resources, belong to the public as a whole. The theory that a man may take from his property all the water which he may desire to take, regardless of the needs of his neighbors, is no longer tenable. The principle that the water resources belong to the public and may be taken for public use upon payment of just compensation is recognized in the Constitution of more than one of the New England States. While many of the earlier decisions tend to hold to the old English Law of quasi-riparian rights, more recent decisions would appear to recognize the common good.

During the drought of 1949-50 there have been occasions where the use of ground waters by private individuals or for industry or agricultural purposes has tended to affect adversely the amount of water obtained from public water supplies. This is a matter which will require more and more attention, as the use of water for both public and private agencies increases.

The Committee is informed by the Water Resources Branch of the U. S. Geological Survey that ground-water conditions were lower in certain areas, especially during the Summer and Fall of 1949, than at any time for many years. From records of ground-water elevations that have been kept, it is interesting to note that in one of the States the greater number of those municipalities experiencing water shortage during 1949 were supplied from ground-water sources. This is easily understandable since, except in buried rock valleys and in the large sandy plains of Cape Cod containing depths of 80 to 90 feet of water-bearing material, the ground-water storage facilities are relatively small, compared with the reservoirs developed for surface-water supply.

Respectfully submitted for the Committee,

(*Signed*) FRANCIS H. KINGSBURY, *Chairman*

Appendix I

Accumulated Departure from Normal Rainfall

June 1, 1949 - August 31, 1950

Month	Maine		New Hampshire	Vermont	Massachusetts			Rhode Island	Connecticut	
	Central	Southern	Southern		Western	Central	Eastern		Western	Eastern
1949										
June	—0.78	—1.88	—1.94	—1.33	—2.33	—3.02	—2.88	—3.27	—2.37	—2.79
July	—1.91	—3.47	—3.12	—1.01	—2.21	—5.19	—5.09	—5.10	—3.08	—3.94
Aug.	—3.87	—4.73	—3.58	—0.49	—2.76	—6.56	—7.10	—6.10	—4.05	—3.92
Sept.	—3.12	—4.13	—2.26	—0.74	—3.25	—6.57	—6.23	—5.95	—5.05	—3.32
Oct.	—4.87	—4.41	—3.02	—1.69	—4.13	—7.74	—8.14	—7.56	—5.85	—4.52
Nov.	—2.85	—3.95	—3.34	—2.06	—6.60	—9.09	—8.70	—7.95	—7.11	—5.19
Dec.	—4.08	—5.73	—4.84	—2.46	—6.68	—10.17	—10.05	—9.56	—7.20	—5.65
1950										
Jan.	—3.13	—4.97	—3.41	—1.57	—5.26	—9.60	—9.93	—10.08	—7.47	—6.06
Feb.	—3.07	—5.93	—3.59	—1.62	—4.28	—9.02	—9.80	—9.49	—7.75	—6.30
Mar.	—4.11	—4.71	—3.51	—1.41	—5.23	—9.45	—10.20	—9.91	—8.85	—7.44
Apr.	—4.00	—5.40	—3.92	—2.03	—5.55	—9.54	—10.86	—11.36	—9.59	—8.41
May	—5.72	—7.58	—5.41	—3.57	—5.60	—10.25	—11.95	—12.15	—9.32	—6.27
June	—4.70	—7.65	—6.56	—3.38	—5.65	—11.39	—13.20	—13.45	—8.60	—5.93
July	—6.20	—10.15	—8.94	—4.29	—6.30	—12.42	—14.90	—15.63	—9.18	—7.15
Aug.	—5.65	—8.95	—7.54	—2.99	—6.91	—12.10	—14.36	—14.30	—8.42	—6.09

Appendix II

Month	Little Androscoggin River near South Paris, Maine					Saco River at West Buxton, Maine				
	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency
1949										
June	38.4	0.45	1.17	—.72	—.72	63.8	1.09	1.71	—.62	—.62
July	30.6	0.16	.52	—.36	1.08	56.6	0.58	1.02	—.44	1.06
August	19.8	0.07	.35	—.28	1.36	40.1	0.32	.80	—.48	1.54
September	21.2	0.09	.42	—.33	1.69	63.2	0.54	.85	—.31	1.85
October	26.2	0.19	.73	—.54	2.23	62.9	0.60	.85	—.25	2.10
November	57.7	0.76	1.32	—.56	2.79	68.2	0.97	1.42	—.45	2.55
December	76.1	1.15	1.51	—.36	3.15	67.0	1.18	1.76	—.58	3.13
1950										
January	120	1.29	1.08	+ .21	2.94	124	2.09	1.68	+ .41	2.72
February	111	0.80	.72	+ .08	2.86	152	1.71	1.12	+ .59	2.13
March	122	2.03	1.66	+ .37	2.49	89.7	1.97	2.20	— .23	2.36
April	131	8.64	6.60	+2.04	.45	126	7.52	5.97	+1.55	.81
May	60.0	1.78	2.97	—1.19	1.64	79.4	3.78	4.76	— .98	1.79
June	112	1.32	1.18	+ .14	1.50	113	1.92	1.71	+ .21	1.58
July	47 9	0.25	.52	— .27	1.77	65.0	0.68	1.05	— .37	1.95
August	66.1	0.23	.35	— .12	1.89	60.5	0.49	.81	— .32	2.27

APPENDIX II (*Continued*)

	PISCATAQUIS RIVER NEAR DOVER-FOXCROFT, MAINE					WHITE RIVER AT WEST HARTFORD, VT.				
Month	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency
1949										
June	38.2	0.58	1.52	—.94	—.94	42	.51	1.21	—.70	—.70
July	54.8	0.33	.60	—.27	1.21	33	1.26	.79	—.53	1.23
August	37.2	0.13	.35	—.22	1.43	68	.31	.46	—.15	1.38
September	48.3	0.16	.33	—.17	1.60	76	.36	.47	—.11	1.49
October	15.9	0.17	1.07	—.90	2.50	61	.39	.64	—.25	1.74
November	58.6	1.10	1.88	—.78	3.28	52	.66	1.27	—.61	2.35
December	79.0	1.25	1.58	—.33	3.61	141	1.77	1.25	+.52	1.83
1950										
January	124	1.35	1.09	+ .26	3.35	177	2.19	1.24	+.95	.88
February	119	0.69	.58	+ .11	3.24	145	1.23	.85	+.38	.50
March	132	1.75	1.33	+ .42	2.82	81	1.99	2.46	—.47	.97
April	121	9.47	7.82	+1.65	1.17	108	7.00	6.48	+.52	.45
May	52.4	2.96	5.65	—2.69	3.86	77	2.24	2.91	—.67	1.12
June	163	2.48	1.52	+ .96	2.90	101	1.23	1.21	+.02	1.10
July	98.0	0.59	.60	— .01	2.91	45	.36	.79	—.33	1.43
August	117	0.41	.35	+ .06	2.85	53	.25	.46	—.21	1.64

APPENDIX II (*Continued*)

	PEMIGEWASSET RIVER AT PLYMOUTH, N. H.					WARE RIVER AT COLD BROOK, MASS.				
Month	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency
1949										
June	54	.89	1.65	—.76	— .76	40	.52	1.30	—.78	—.78
July	41	.47	1.15	—.68	—1.44	28	.20	.71	—.51	1.29
August	83	.55	.66	—.11	—1.55	31	.13	.42	—.29	1.58
September	142	1.10	.77	+.33	—1.22	40	.18	.45	—.27	1.85
October	78	1.06	1.36	—.30	—1.52	34	.22	.65	—.43	2.28
November	97	1.98	2.04	—.06	—1.58	28	.33	1.18	—.85	3.13
December	142	2.32	1.63	+.69	— .88	64	1.01	1.58	—.57	3.70
1950										
January	192	2.63	1.37	+1.26	+ .37	115	2.20	1.91	+.29	3.41
February	160	1.30	.82	+ .48	+ .85	104	1.58	1.52	+.06	3.35
March	101	1.98	1.96	+ .02	+ .87	88	3.14	3.57	—.43	3.78
April	128	8.00	6.25	+1.75	+2.62	95	4.06	4.27	—.21	3.99
May	79	3.82	4.84	—1.02	+1.60	82	2.00	2.44	—.44	4.43
June	149	2.48	1.65	+ .83	+2.43	89	1.16	1.30	—.14	4.57
July	57	.65	1.15	— .50	+1.93	58	.42	.72	—.30	4.87
August	64	.42	.66	— .24	+1.69	54	.22	.41	—.19	5.06
Water year								23.3		

APPENDIX II (*Continued*)

Month	Wading River near Norton, Mass.					Quinebaug River at Jewett City, Conn.				
	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency	% of median	Runoff in inches	Median	Deficiency	Cumulative deficiency
1949										
June	51	.55	1.08	—.53	—.53	61	.78	1.28	—.50	—.50
July	39	.20	.51	—.31	.84	41	.30	.73	—.43	.93
August	29	.12	.41	—.29	1.13	50	.32	.64	—.32	1.25
September	29	.13	.45	—.32	1.45	57	.39	.68	—.29	1.54
October	26	.13	.50	—.37	1.82	40	.30	.75	—.45	1.99
November	26	.25	.96	—.71	2.53	41	.46	1.12	—.66	2.65
December	38	.61	1.60	—.99	3.52	48	.86	1.79	—.93	3.58
1950										
January	37	.88	2.38	—1.50	5.02	68	1.56	2.30	—.74	4.32
February	74	1.66	2.24	— .58	5.60	101	1.93	1.91	+.02	4.30
March	75	3.00	4.00	—1.00	6.60	92	3.30	3.59	—.29	4.59
April	69	2.25	3.26	—1.01	7.61	103	3.24	3.15	+.09	4.50
May	71	1.48	2.08	— .60	8.21	125	2.63	2.10	+.53	3.97
June	53	.56	1.08	— .42	8.63	139	1.78	1.28	+.50	3.47
July	39	.20	.51	— .31	8.94	92	.67	.73	—.06	3.53
August	56	.22	.41	— .19	9.13	108	.69	.64	+.05	3.48

COMMITTEE TO REPORT ON DEVELOPMENTS IN OUR KNOWLEDGE OF CORROSION AND ITS MITIGATION

Report on Experiences in the Use of Metaphosphate in Massachusetts

To the President and Members of the New England Water Works Association:

The use of small concentrations of certain complex phosphates to inhibit corrosion of metallic piping was first begun in 1939. The chief experience in Massachusetts has been with a commercial compound, sold under the trade name of "Calgon" and consisting of a polymetaphosphate. The usual practice is to apply this material to the water supply at the rate of about 10 ppm for several days; this application should be accompanied by thorough flushing at hydrants on the dead ends of the system. The dosage is then reduced to about 0.5 to 2.0 ppm. The inhibiting action is said to be due not to a change in the corrosive properties of the particular water supply, but to the formation of a protective layer of metaphosphate compounds one molecule thick on the metallic surface. This form of treatment is being used or has been used within the last 10 years by some 20 to 30 municipalities in Massachusetts. The following is a summary of some of the experiences with metaphosphate treatment.

Ferrous Metals

In general this form of treatment has been adopted mostly by municipalities where "red water" conditions were serious enough to cause general public dissatisfaction with the water supply. Illustrative of the results obtained are the following data at the beginning of metaphosphate treatment in one of our municipalities. In this case the supply involved was a surface supply, low in color, iron and dissolved mineral matter. There was considerable difficulty with iron at dead ends, especially during the winter months. Treatment was started at 10 ppm and simultaneously extensive flushing was carried on all over the town, until metaphosphate was found well distributed

TABLE 1.—EFFECT OF METAPHOSPHATE TREATMENT
(Parts per Million)

Date of collection		Reservoir			Station 1, tap			Station 2, tap			Station 3, tap		
		Color	Iron	Meta-phos-phate	Color	Iron	Meta-phos-phate	Color	Iron	Meta-phos-phate	Color	Iron	Meta-phos-phate
February	19	—	—	0.0	—	—	0.0	30	1.0	0.0	12	0.35	0.0
	20*	—	—	—	—	—	0.0	8	0.35	8.0	—	—	—
	21	5	0.05	0.0	7	0.25	0.0	12	0.60	5.8	8	0.30	6.8
	22	—	—	—	—	—	—	33	1.7	5.4	20	0.80	9.4
	23	—	—	—	—	—	—	32	1.7	4.1	12	0.35	8.5
	24	—	—	—	—	—	—	32	1.5	3.8	25	0.70	10.0
March	3	3	0.05	0.0	15	0.50	0.0	13	0.60	0.7	22	0.70	1.7
	10	8	0.05	0.0	15	0.42	0.0	22	0.40	0.9	12	0.25	1.8
	17	4	0.05	0.0	—	—	—	8	0.30	0.2	8	0.40	1.7
	24	—	—	—	38	1.3	0.9	12	0.30	0.0	13	0.32	0.9
		Station 4, tap			Station 5, tap			Station 6, tap			Station 7, tap		
February	19	22	0.45	0.0	80	2.2	0.0	33	0.75	0.0	—	—	0.0
	20*	—	—	—	—	—	—	—	—	—	—	—	—
	21	8	0.50	10.4	8	0.30	9.1	8	0.50	10.6	—	—	—
	22	32	1.5	7.3	22	1.0	10.0	35	1.6	10.0	18	0.55	7.1
	23	38	1.6	4.0	23	1.5	6.4	35	1.6	6.0	25	1.3	3.4
	24	32	1.5	3.4	20	1.5	6.7	35	1.7	5.9	28	1.6	6.3
March	3	20	0.75	0.8	27	1.3	1.6	35	1.3	1.7	28	1.2	2.1
	10	13	0.40	0.6	17	0.35	1.5	13	0.40	1.4	13	0.40	1.3
	17	10	0.30	1.1	13	0.30	0.5	7	0.22	1.5	7	0.28	2.2
	24	6	0.20	0.0	8	0.30	0.3	12	0.35	0.2	10	0.30	0.1

*Metaphosphate treatment started.

throughout the system. Samples were collected before treatment was begun and for some time afterwards from the reservoir and from a number of taps throughout the town, especially on dead ends. Table 1 summarizes the results of analyses.

While the initial drop in the color and iron content was doubtless due to the thorough flushing, the subsequent rise in both of these to a point higher than before treatment indicates a temporary increase in the solvent action of the water on the mains. The subsequent drop in iron and color content may be attributed to the inhibiting effects of metaphosphate.

Subsequent tests on the same taps have indicated that the iron content has been low and in some instances, as at "Station 1", has dropped even lower to satisfactory levels.

Similar results following metaphosphate treatment for "red water" have been reported by most municipalities employing this type of treatment. Less satisfactory results have in general been limited to supplies such as those at summer resorts, where the period of storage in certain mains may vary quite markedly at various times of the year.

Brass and Copper Piping

While the use of metaphosphate treatment has been undertaken solely for the inhibition of corrosion of brass and copper piping in only a few instances, both experimental laboratory data and actual field experience have indicated that this form of treatment has not met with any marked success.

An illustration of the results obtained is the following instance involving the use of metaphosphate for corrosion correction. A municipality having a ground-water supply softened in a zeolite unit undertook to reduce the corrosive properties of the treated water by using metaphosphates at the rate of 0.5 to 2.0 ppm. To study the effectiveness of this treatment, samples were collected about every two weeks from several brass service pipes. The copper content was determined on samples of water standing overnight in the pipes and on samples of water from the same taps after considerable flushing. Table 2 gives the data obtained from one such tap over a period of eight months.

TABLE 2.—COPPER CONTENT OF WATER FROM TAP AT 8 POND PARKWAY

1942		Copper (parts per million) Running	Standing
February	9	0.14	—
	10	—	0.65
	24	0.43*	0.60*
March	4	0.30	—
	5	—	0.70
	12	—	0.50
	24	0.33	0.60
April	2	0.62	—
	3	—	0.70
	8	0.13	—
	9	—	1.05
	30	0.42	—
May	1	—	0.80
	12	0.16	—
	13	—	0.26
	27	0.12	0.32
June	10	0.50	0.38
	22	0.60	—
	23	—	0.80
July	14	0.70	—
	15	—	0.45
	27	0.42	—
	28	—	0.55
August	26	—	0.90
September	10	0.80	1.1
October	27	0.60	—

*Calgon treatment started.

Some time after these data had been accumulated there was a marked increase in the number of complaints of blue stains on plumbing fixtures and leaks in various brass services being served with this water. As a result the water department discontinued the use of metaphosphate treatment.

LEAD PIPING

No instance has come to our attention where metaphosphate treatment has been undertaken by a municipality solely for the purpose of inhibiting the corrosion of lead pipe; rather, concern has been

felt as to the possible effects on the corrosion of lead pipe, where metaphosphate treatment has been undertaken to inhibit corrosion of ferrous metals or for some other reason.

When metaphosphate treatment was installed in a municipality using a ground-water supply, the effect of such treatment on the storage of water in lead pipe was studied. Over a period of seven months, samples taken from several lead service lines, both of water standing in the pipes overnight and of water collected after the pipes had been thoroughly flushed, showed no evidence of any increased lead content due to the use of this chemical. The metaphosphate was used in dosages varying from 0.5 to 2.0 ppm. The pH of this water was about 6.3. Table 3 summarizes the results of both running and standing samples.

TABLE 3.—SUMMARY OF LEAD RESULTS*

Source	Date 1942	Lead (parts per million) Standing sample	Running sample
Tap A	2/9	—	.01
"	2/24	—	.04
"	3/5	.05	.01
"	3/12	.06	.00
"	3/24	.05	.00
Tap B	4/3	.08	.00
Tap C	4/9	.02	.00
"	5/1	.27	.03
"	5/13	.13	.07
"	5/28	.15	.03
"	6/10	.07	.03
"	6/23	.04	.03
"	9/10	—	.07
Tap D	7/28	.05	.01

*Metaphosphate dosage 0.5 to 2.0 parts per million.

Laboratory studies have been carried out on the effects of the use of metaphosphate on the storage of water in lead pipe. In these experiments both new lead pipe and old lead pipe, which had been in service from 10 to 30 years, were used. Water was allowed to flow through these pipes over a period of 8 hours each day at the rate of 250 gal per day. The pH of the water during these experiments was held at 6.1, 6.7 and 8.0 to 8.4, each set being run over a period of

2 to 3 months. Samples of both the running water and the water after storage in the pipe overnight were collected. In general, these experiments indicated that the effectiveness of the metaphosphate treatment in controlling corrosion is dependent upon the pH of the water being used. It was found that at a pH of 6.1, after a short interval in which results were indeterminate, the corrosive effect of the water on lead pipe was being retarded by the use of metaphosphate. At a pH of 6.7, the retarding effect did not begin for a considerably longer period after treatment was initiated, but after some time this retarding effect was noticeable although slight. At a pH of 8.0 to 8.4, there were definite indications that the corrosive effect of the water on the pipe had been increased and considerably more lead was being dissolved by the water in both the running and standing samples. The metaphosphate dosages used varied between 2.0 and 10 ppm, but the results were not markedly different as between these two values.

Respectfully submitted,

(*Signed*) EDWARD W. MOORE, *Chairman*
LAZARUS RUBIN
WALTON H. SEARS

FINAL REPORT OF THE COMMITTEE ON WATER QUALITY TOLERANCES FOR INDUSTRIAL USES

August 8, 1950

To the President and Members of the New England Water Works Association:

The Committee on Water Quality Tolerances for Industrial Uses was established by the Association in November of 1938. The duties of the Committee were to investigate and report on the quality of process water required by industry, with special attention to limits of tolerance for substances known to interfere with industrial processes. The Committee presented an extensive report in June, 1940, containing tables of tolerance limits for waters for a number of industries, and text material describing the effects of various harmful substances in water on industrial operations. This report was well received by the Association and by the profession in general, but some valid criticism was directed at the tolerance limits proposed, principally because these limits tended to be too severe. It was stated by qualified individuals that in certain instances industrial plants were turning out a perfectly satisfactory product, using water of quality inferior to that specified in the Committee's report.

The Committee accepted these criticisms as an indication of the necessity for investigating such instances and gathering all possible information, with the objective of subsequently revising its proposed tolerance limits. It has not proved to be possible to carry out this plan. Those industrial operators, whose water supplies may be inferior to the specifications of the Committee, prove on investigation to be either completely ignorant of the quality of water used in their processes, or else unwilling to impart necessary information for competitive or other reasons. Those operators who are aware of the water-quality problem and are willing to impart information generally are using waters which conform substantially to the Committee's specifications. Although there has been a change in the quality requirements set by industries in the direction of lower tolerances, the

Committee sees no reason for altering its original table of tolerances, as published in the JOURNAL of the Association, Volume 54, pages 271-272, 1940.

Undoubtedly, there are still a number of plants which use water of quality inferior to that indicated by the Committee's table. However, to determine where these plants are, how their operations differ from those of other plants, and particularly whether or not the inferior water has some adverse effect on product or adds in some degree to cost of production, is deemed by the Committee to be an insurmountable task, unless members could be found who were willing to devote a large amount of time to the work. The present Committee is unable to perform this task.

A number of articles on various aspects of industrial water supply have been published since 1940 and some of the more pertinent ones are listed here:

A. REFERENCES ON SPECIFIC INDUSTRIES

Brewery Water and Its Analysis. J. deClerck. Chemie et Industrie, *59*, 484 (1948).

New Developments in Water Conditioning for Diesel Cooling Systems and Steam Generators. M. A. Hanson *et al.* American Railway Engineering Association Bulletin 483, 134 (1949).

Effect of Fluoridated Water in Ice Manufacture. Zachary M. Stadt and Robert S. Phillips. Journal, American Water Works Association, *41*, 1069 (1949).

Specifications for Process Water for Groundwood Papers. Paper Trade Journal, *126*, 105 (1948).

Process Water for the Manufacture of Alkaline Pulps. Lewis B. Miller. TAPPI *32*, No. 6, 41A (1949).

B. REFERENCES ON GENERAL ASPECTS OF INDUSTRIAL WATER

Industrial Waters of Canada. H. A. Leverin. Report on Investigations, 1934-1940, and Interim Report No. 6, Memo Series No. 85, 1944, Department of Mines and Resources, Canada.

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In conclusion, it appears evident to the membership of the Committee that the amount of additional information which can be readily secured on industrial water-quality tolerances is limited to that given in occasional articles in the literature, and that direct investigation of individual plants by the Committee is not feasible except through a prohibitive expenditure of time. The Committee, therefore, recommends that it be either discontinued or assigned the more limited objective of keeping the membership informed as to new developments appearing in the literature.

Respectfully submitted,

(*Signed*) EDWARD W. MOORE, *Chairman*
HERVEY J. SKINNER
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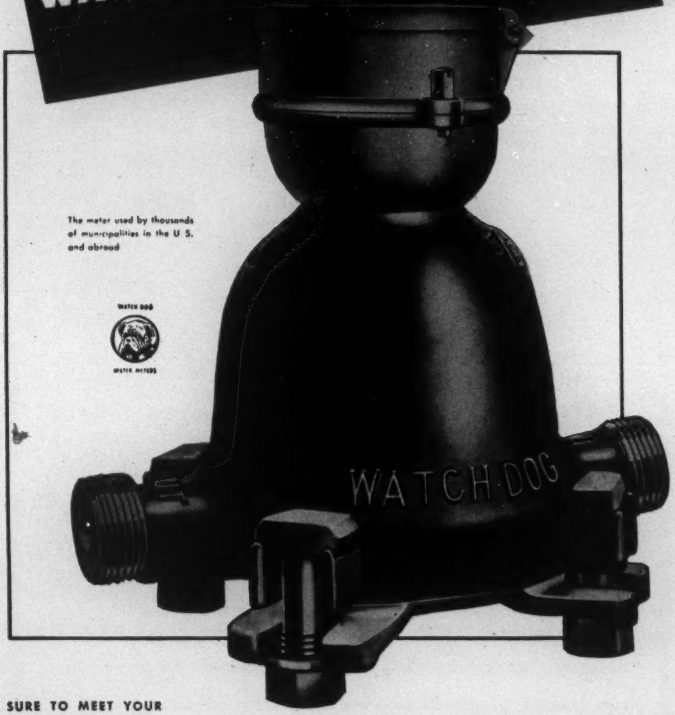

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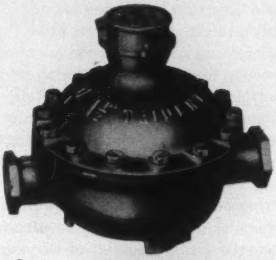

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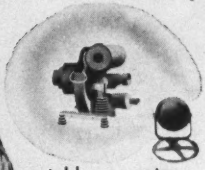

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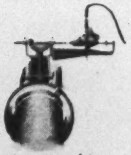

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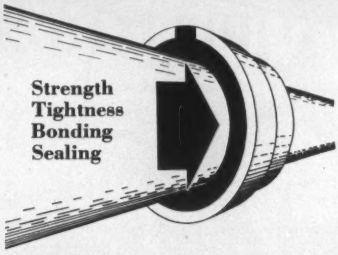

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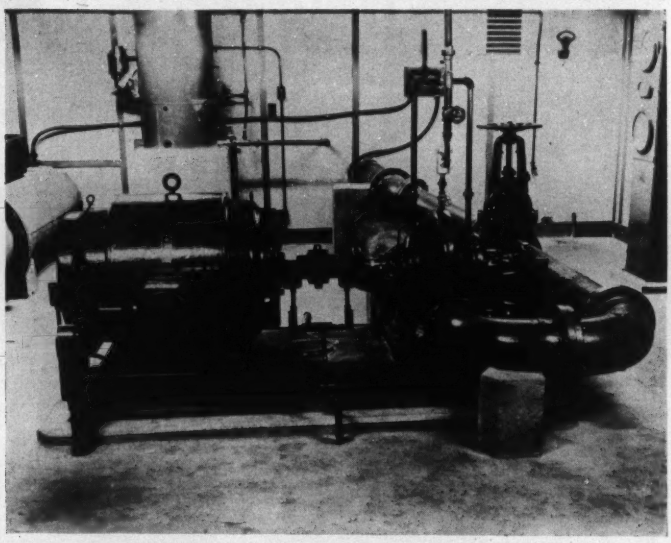

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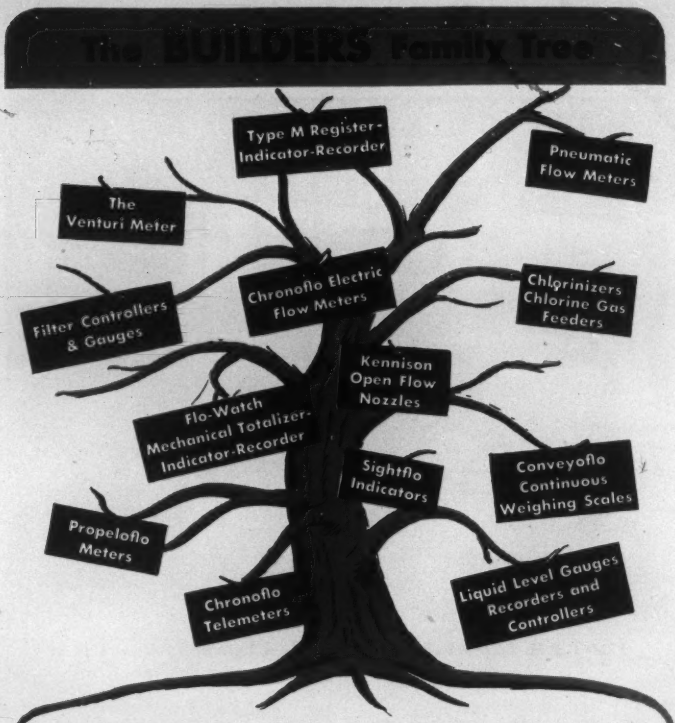

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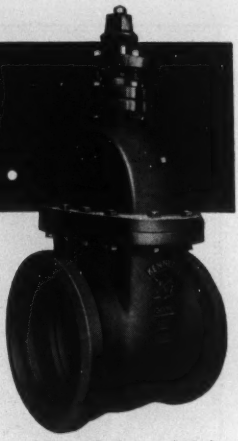

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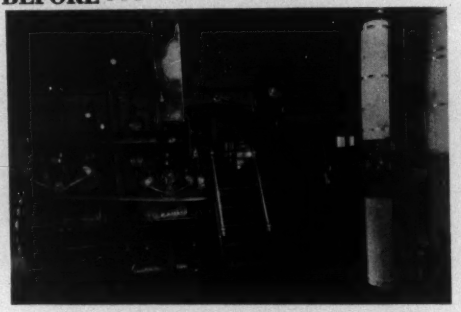

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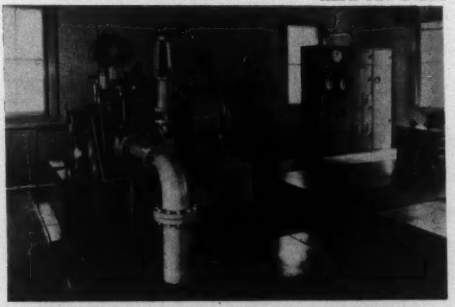

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Don't take chances with inferior caulking lead which may have been manufactured from scrap material containing a large percentage of impurities.

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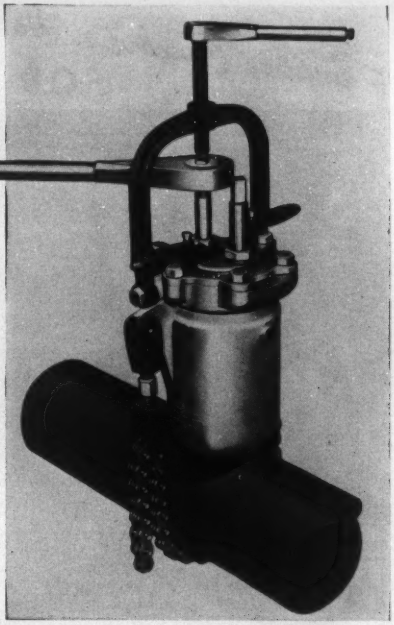
MODEL B TAPPING MACHINE

FOR INSERTING ALL STANDARD MAKES OF CORPORATION STOPS



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EASIER HANDLING . . . Shorter height • More rigid attachment to the main • More room in the ditch • Fewer operations—less physical effort required

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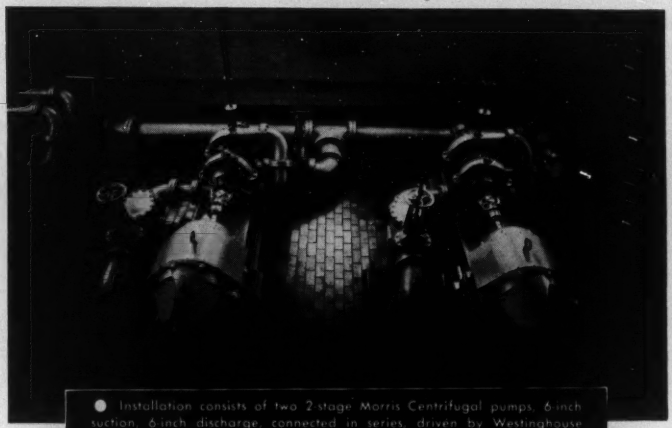
WATER WORKS PRODUCTS
HAYS MANUFACTURING CO., ERIE, PA.

Pumping Concord's Water

FOR 19 YEARS...



● Installation consists of two 2-stage Morris Centrifugal pumps, 6-inch suction, 6-inch discharge, connected in series, driven by Westinghouse 125 H.P. motors at a speed of 1740 R.P.M.; capacity of each unit 1145 gallons per minute with suction lift of 15 feet and discharge head 286 feet.

The third unit is a 3-stage Morris Centrifugal pump connected in series, driven by a 175 H.P. Sterling Dolphin gas engine, 1200 R.P.M., 1145 gallons per minute.

MORRIS *Centrifugal* PUMPS

In 1930, the contract for pumping equipment in the new Meadow Station at Concord, New Hampshire was awarded to the Starkweather Engineering Company of Newtonville, Mass. Three Morris Centrifugal Pumps were then installed—nineteen years ago.

Since then the Morris Pumps have given such excellent service, according to the superintendent of the Water Department, that the Town ordered, and now has in operation, a fourth Morris Pump for the Main Station.

Another example of MORRIS SERVICE with EFFICIENCY . . .

There is a Morris Pump for every job. Write us for specification and operation data best suited to your needs. No charge or obligation.

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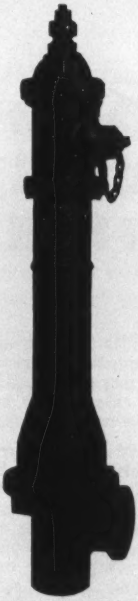
MORRIS *Centrifugal Pumps*

EDDY

Valves and Hydrants

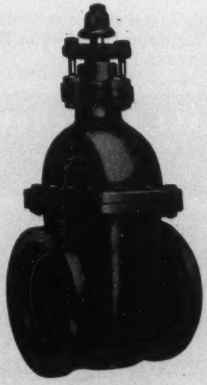


Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.



Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

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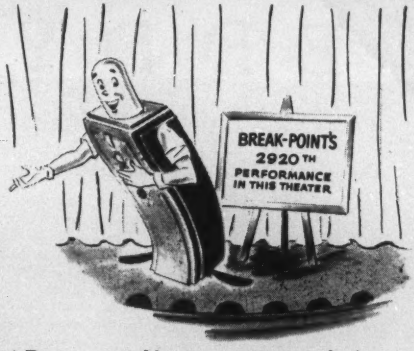
8 YEARS AND STILL GOING STRONG



The ability of the Break-Point Process to meet the various demands of day by day operation is aptly shown by the case history of a municipal water works in Pennsylvania.

Since 1941, when it was installed at this plant by W&T Engineers, the Break-Point Process has played a major role in producing a pure, sparkling water for the system's many consumers. It has completely eliminated complaints on tastes and odors and has raised the finished water quality to such a high level that tests show *no* gas formers and *no* bacteria on the plates. In addition, a staff report continues, the Break-Point Process was of particular value in keeping the water acceptable to consumers during an emergency plant overload of 120%.

These accomplishments and such additional benefits as longer filter runs and iron and manganese removal are typical of what you receive with the Break-Point Process backed by W&T Equipment.

In the complete line of W&T chlorinating equipment, proved by over 35 years' experience all over the world, there is a chlorinator that will give *your* plant these benefits, too.

For more details write to your nearest W&T Representative — he'll be glad to help you.

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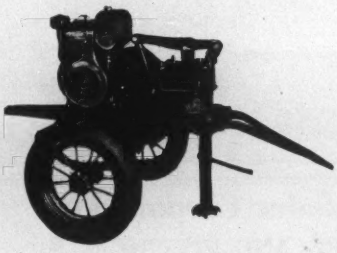
EDSON

PUMPS and ACCESSORIES



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1879—ROSS— 1879

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Controls elevation of water in tanks, basins and reservoirs

ALTITUDE VALVE

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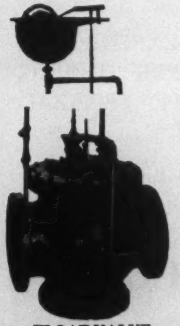
Maintains desired discharge pressure regardless of change in rate of flow

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.



Maintains levels in tank, reservoir or basin

1. As direct acting

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

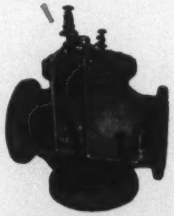
FLOAT VALVE

A self contained unit, with controls three or more automatic

COMBINATION VALVE

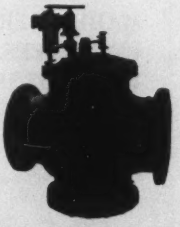
Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge



SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

ROSS VALVE MFG. CO., INC. Box 592 TROY, N. Y.

Fig. 50

RED HED Y Branches

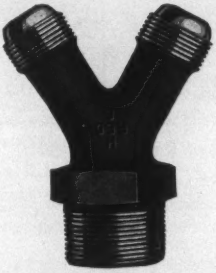


Fig. 440 M

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RED HED BRASS GOODS COST LESS BECAUSE THEY ARE BETTER.

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RED HED Brass Goods for Water Works

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No question about it; the most popular beverage of all is good drinking water—water that tastes right, smells right and looks right.

And there's no reason for water not to be "right." Where Welsbach Ozonating equipment is used, consumers know the pleasure of drinking water free from disagreeable chlorinous odors, offensive "medicinal" tastes and objectionable color.

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Everybody wants improved drinking water—and all communities can now have it. Water technicians, city officials and consulting engineers particularly will be interested in the Welsbach-Ozone story. They are invited to write about their water difficulties to The Welsbach Corporation. A frank, factual analysis will be made—at no cost or obligation. Also ask for, "Are Bathless Thursdays Really Necessary?", the picture story booklet about the Welsbach-Ozone process and equipment.

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Ozone Processes Division

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Tegul-MINERALEAD*

AND

HYDE-RO RINGS

the best way

to join

bell and spigot pipe

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FREQUENT OPERATION
THROTTLING
VERTICAL PIPE LINES

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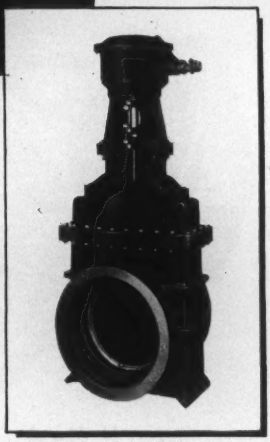

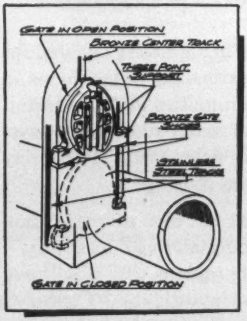

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4—The gates are properly supported for operating in vertical lines.

YOU know that throttling service leaves a valve partially open—in which case, an improperly supported downstream gate is under pressure to tilt into the downstream port opening and to score the face of both gate and seat rings.

THIS CAN'T HAPPEN in a Rensselaer Square Bottom Gate Valve—because the gate is properly supported at THREE POINTS during its full length of travel. It can't tilt. The diagram shows why, in detail.

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Without obligation on your part a Rensselaer representative will be glad to give you the benefit of his experience in Valves, Hydrants and other Rensselaer products. Call our nearest office.

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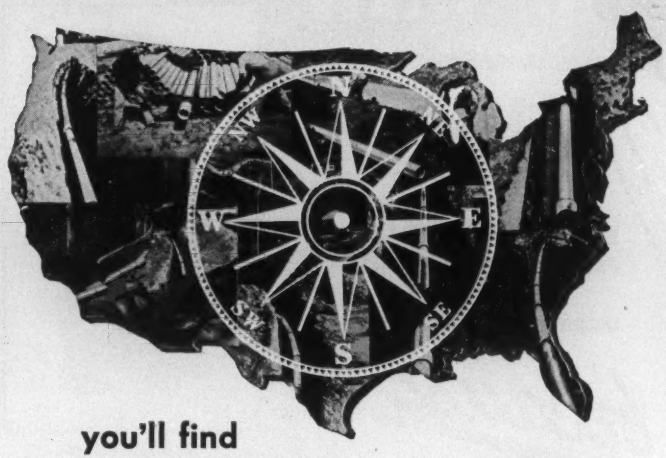

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Low cost . . . ease of installation . . . outstanding durability—three big reasons why it will pay you to investigate "Century" Asbestos-Cement Pipe for your next water main installation! Write us for complete information.

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